THE IMPACT OF COURSE DESIGN AND DELIVERY METHODS ON STUDENT OUTCOMES IN THE FOUNDATION SURVEYING-GEOMATICS COURSE

A Dissertation
Presented to
The Academic Faculty

By

Roger C. Purcell

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in the
School of Civil and Environmental Engineering

Georgia Institute of Technology
August 2014

THE IMPACT OF COURSE DESIGN AND DELIVERY METHODS ON STUDENT OUTCOMES IN THE FOUNDATION SURVEYING-GEOMATICS COURSE

Approved by:

Dr. Michael O. Rodgers, Advisor
School of Civil and Environmental
Georgia Institute of Technology

Dr. Randall L. Guensler
School of Civil and Environmental
Engineering
Georgia Institute of Technology

Dr. Adjo Amekudzi Kennedy
School of Civil and Environmental
Engineering
Georgia Institute of Technology

Dr. Catherine Ross
School of City and Regional Planning
Georgia Institute of Technology

Dr. Darryl J. Hancock
School of Distance Learning
Middle Georgia State College

Date Approved: June 30, 2014

This work is dedicated to my extraordinary wife, Nancy, as well as family and friends. Without all of their support and kindness, my efforts contained herein would be for naught.

ACKNOWLEDGEMENTS

There are several people and organizations that have helped me make this work possible. In particular, I would like to thank the Faculty and Administration of Middle Georgia State College for the support that they have provided ever since I started this effort. Allowing me to have a year to start my coursework at Georgia Tech was essential for me to get off to a good start.

I would like to thank my advisor, Dr. Michael O. Rodgers, from the School of Civil and Environmental Engineering for his never ending guidance and support. He certainly has been a great leader to help me navigate through this effort which has been no small chore given that much of my work has been done from a distance.

I would like to thank my committee for their support and willingness to be part of this effort. Dr. Randall L. Guensler and Dr. Adjo Amekudzi Kennedy from the School of Civil and Environmental Engineering and Dr. Catherine Ross from the School of City and Regional Planning are leaders in their respective fields of instruction and research at the *Georgia Institute of Technology*. Also, I am very grateful to Dr. Darryl J. Hancock of *Middle Georgia State College* for being part of this effort and for always being available for consultation.

I would like to thank the staff members and my colleagues at Middle Georgia State College for their support. In particular, I would like to thank Mr. Richard Burnam for his help with data acquisition from the Middle Georgia State College databases.

I would like to thank Dr. Karen J. Head and Dr. Tris Utschig of Georgia Tech's Center for the Enhancement of Teaching and Learning for their support and guidance when the going was slow.

I would like to thank my Heavenly Father for his guidance and allowing me to experience this adventurous undertaking. Also, I would like to thank my parents for their love and their guidance in tenacity and in the ability to get things done.

Finally, I would like to thank my wife, Nancy, and all of my family and friends for their love and support through this journey. I truly could not have done this without them.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

AAG: Association of American Geographers

ABET: Accrediting Board of Engineering and Technology

AFL: Assessment for Learning

ALT: Academic Learning Time

AOL: Assessment of Learning

ASAC: Applied Science Accreditation Commission

ASPRS: American Society of Photogrammetry and Remote Sensing

CAGIS: Cartography and Geographic Information Society

CQQ: Common Quiz Questions

DEM: Demonstration Methods

D2L: Desire to Learn

EAC: Engineering Accreditation Commission

FE: Fundamentals of Engineering Exam

FGDC: Federal Geographic Data Committee

FIG: International Federation of Surveyors

FSG: Foundation Surveying-Geomatics

FGSC: Foundation Surveying-Geomatics Course

FS: Fundamentals of Surveying Exam

GIS: Geographic Information Systems

GSAMS: Georgia Statewide Academic and Medical System

IAP: individual Assessment Plan

IRB: Institutional Research Board

IT: Information Technology

LiDAR: Light Detection and Ranging

MGC: Middle Georgia College

MGSC: Middle Georgia State College

MTU: Michigan Technical University

NCEES: National Council of Examiners for Engineering and Surveying

NSPS: National Society of Professional Surveyors

PIM: Programmed Instructional Methods

PS: Professional Surveying Exam

SAMSOG: Surveying and Mapping Society of Georgia

SAT: Scholastic Aptitude Test

SBOK: Surveying Body of Knowledge

SED-ASCE: Surveying Engineering Division-American Society of Civil Engineering

S-G: Surveying-Geomatics

TAC: Technical Accreditation Commission

UCGIS: University Consortium for Geographic Information Science

U.S.: United States

USDOE: United States Department of Education

SUMMARY

This research investigates the impact of course design and delivery methods on student outcomes in the Foundation Surveying-Geomatics (FSG) course. As indicated from current literature, fewer civil engineering students are taking surveying-geomatics courses, fewer students are pursuing surveying-geomatics as a career, practicing surveying professionals are retiring at an increasing rate and recently, surveyors are leaving the profession due to poor job opportunities & advancement resulting from poor economic conditions. These occurrences provide an impetus to encourage more students, traditional & non-traditional, and mobile & place-bound, to pursue surveying-geomatics education. Additionally, in order to make their required educational experience successful, educators must make surveying-geomatics coursework both effective & efficient as they train a new generation of surveyors.

This research focuses on students taking the FSG course in an online platform. The importance of these students is highlighted by the knowledge that very few new surveying licenses are being issued. Further, in order to improve the success of these students in their subsequent college coursework and licensure exam performance, student outcomes in the FSG course were examined. In summary, this research was designed to fill some of the gaps in the understanding of how course design and delivery methods impact student outcomes and in the characterization of today's surveying-geomatics students.

The identified objectives of this research included the following:

- To design an assessment plan for the online foundation surveying-geomatics course that optimizes the application of the concept of “assessment for learning” including assessments and supporting applications.
- To develop a data driven model to measure and validate student learning in the online foundation surveying-geomatics course.
- To estimate the effectiveness of the proposed assessment plan using an experimental design that utilizes data from foundation surveying-geomatics course offerings and student input.
- To propose a method based on pre-course student data and academic performance indicators to characterize online surveying-geomatics students and to predict the future performance of the students in the foundation surveying-geomatics course.

In order to facilitate this investigation, an assessment plan including new course design and delivery methods was developed and applied. Additionally, a method to characterize online surveying-geomatics students and to predict their future performance in the FSG course was developed. This method was based on pre-course student data and pre-course academic performance metrics and predicted student performance in the FSG course.

The results of this research indicate that student learning can be improved in the FSG course through the application of an assessment plan that includes course design and delivery tools that best match the student needs. Further, FSG students can be characterized to improve the understanding of the relationship between pre-course student data & pre-course academic performance metrics and the predicted student performance in the FSG course. This research is intended for civil engineering and surveying-geomatics educators and as such has provided knowledge of the impact of a viable assessment plan. In addition, it is hoped that these educators will find the methodology usable, illustrative and applicable to their coursework.

CHAPTER 1

INTRODUCTION

1.1 Research Overview

The purpose of this research is to investigate the impact of course design and delivery methods on student outcomes in the online Foundation Surveying-Geomatics (FSG) course. As indicated from recent course enrollment numbers, fewer students are taking surveying-geomatics courses (Middle Georgia State College. (n.d.). Student Data. Retrieved from http://www.mga.edu/course-schedule/) (Southern Polytechnic State University. (n.d.). Student Enrollment Schedule. Retrieved from https://banweb.spsu.edu/pls/PROD/schedule.main), fewer students are pursuing surveying-geomatics as a career (Georgia S.O.S.- Georgia Board of Professional Engineers & Land Surveyors. (n.d.). Retrieved from http://sos.ga.gov/index.php/licensing/plb/22), based on licensing renewal information, practicing surveying professionals are retiring at an increasing rate and surveyors are leaving the profession due to poor job opportunities & advancement resulting from poor economic conditions. (Georgia S.O.S.- Georgia Board of Professional Engineers & Land Surveyors. (n.d.). Retrieved from http://sos.ga.gov/index.php/licensing/plb/22) Since the demand for surveying and geomatics expertise remains high, these trends portend a future shortage of professionals in this area and provide an impetus to encourage more students, traditional & non-traditional, and mobile & place-bound, to pursue surveying-geomatics education while ensuring that their required educational coursework is both effective & efficient in training this next generation of surveyors.

Traditionally, the FSG course has been delivered in a traditional classroom setting. While effective, this approach limits the range of individuals that can undertake such a program and there is a strong interest in developing online versions of this traditional course. (Wijayratne, 2005) Based on recent trends, online surveying-geomatics students represent a significant percentage of newly licensed surveying professionals. Thus, the needs of these online students must be addressed in order to educate an adequate number of surveyors for the 21st century. It was noted that a number of online surveying-geomatics courses have been developed, but there has been relatively little research conducted on the improvement of the online approach for these courses which is a primary focus of this research.

In order to address this research void, this study evaluates students taking the FSG course in an online platform under two different assessment plans. Further, this evaluation included specific student outcomes from the FSG course which were directly tied to the success of these students in their subsequent college coursework and licensure exam performance. With the intent of improving student learning in the online FSG course, this research was designed to fill some of the gaps in the understanding of how course design and delivery methods impact student outcomes and in the characterization of today's surveying-geomatics students.

The identified objectives of this research included the following:

- Design an assessment plan for the online foundation surveying-geomatics course that optimizes the application of the concept of "assessment for learning" including assessments and supporting applications.
- Develop a data driven model to measure and validate student learning in the online foundation surveying-geomatics course.

- Estimate the effectiveness of the proposed assessment plan using an experimental design that utilizes data from foundation surveying-geomatics course offerings and student input.
- Propose a method based on pre-course student data and academic performance indicators to characterize online surveying-geomatics students and to predict the future performance of these students in the foundation surveying-geomatics course.

To facilitate this investigation, an assessment plan including new course design and delivery methods was developed. The pilot version of the assessment plan was applied to the Spring 2012 offering of the FSG course, SURV 2501 Plane Surveying, at Middle Georgia State College, (Cochran, Georgia). After refinements were made from lessons learned from the pilot course, the experimental course was offered in Fall 2012, Spring 2013, Summer 2013 and Fall 2013. The control course offerings were based on traditional methods. These offerings took place in Spring 2009, Summer 2010, Fall 2010, Summer 2011 and Fall 2011. Utilizing data from these control and experimental courses, a data driven model to measure and validate student learning in the online FSG course was developed and applied to estimate the effectiveness of the proposed assessment plan.

Additionally, a method to characterize online surveying-geomatics students was developed and a framework to predict their future performance was introduced. These methods were based on pre-course student data and pre-course academic performance metrics. Three study periods were studied as follows:

- Spring 2003 through Summer 2009
- Spring 2009, Summer 2010, Fall 2010, Summer 2011 and Fall 2011

- Fall 2012, Spring 2013 and Summer 2013

An analysis of the data from the Spring 2003 through Summer 2009 group yielded key variables and relationships between these key variables & student academic performance in the FSG course. Also, student groupings to be used in the analysis of student learning were identified.

The results of this analysis indicated that student learning can be improved in the FSG course through the application of an assessment plan that focuses on “assessment for learning” and that includes course design and delivery tools that best match the student needs. Further, FSG students can be characterized to improve the understanding of the relationship between pre-course student data & pre-course academic performance metrics and the predicted student performance in the FSG course. This research was intended for civil engineering and surveying-geomatics educators and as such has provided knowledge of the impact of a viable assessment plan. In addition, it is hoped that these educators will find the methodology usable, illustrative and applicable to their coursework.

1.2 Organization of the Dissertation

In as much as possible, this dissertation follows the chronological order of the research. However, some key research elements were being pursued simultaneously and thus this order is not absolute. This section is intended to provide an outline of the subsequent chapters and will provide an overview of the review of associated literature, the development & application of the quasi-experimental model, results, findings, limitations and future research.

The next chapter, Chapter 2, covers the literature that was examined to support the research. First, the educational needs of the surveying-geomatics professional were examined and online teaching approaches & pedagogy for surveying-geomatics courses (and technical courses in general) were reviewed and mined down to focus on assessment applications. In addition, previous surveying-geomatics student (general technical-engineering student) characterizations and efforts to relate student characteristics to student academic performance were explored. Previous efforts to develop student metrics including student performance on licensure exams as related to student academic program performance were also examined.

Chapter 3 is devoted to the development of a new way to educate online surveying-geomatics students utilizing “assessment for learning”. Thus, Chapter 3 begins with an examination of the assessment methodology contained in the control course offerings of the FSG course, then, identifies the ideal FSG course characteristics and describes the development of an assessment plan containing the “assessment for learning” concept. (McKinny, 2011) Proceeding forward, the pilot application of the FSG course in Spring 2012 is summarized along with refinements to the FSG course based on lessons learned from the pilot application of the course.

Chapter 4 covers the application of the assessment plan as contained in the experimental FSG course offerings and highlights the selection of common quiz questions and the control test. Chapter 5 provides a detailed examination of data sources used in the research including multiple databases and data processing as required for data analysis in Chapter 6. In Chapter 6, student characterization was performed for the three online student groups (introductory group, control group and experimental group) and includes key variable selection and grouping.

Chapter 7 provides analysis of student learning by comparison of student performance on common questions & control tests as contained in the experimental course offerings versus the control course offerings. Chapter 8 provides the conclusions of the research by summarizing the research findings and detailing the limitations of the research, the need for future research & the projected future research concepts. Finally, Chapter 9 looks from a larger overview perspective at the problems facing the s-g profession in education and at many other general challenges. Chapter 9 concludes with the restatement of the needs for future research in order to help the s-g profession survive.

CHAPTER 2

BACKGROUND

As indicated in Chapter 1, the purpose of this research is to complete the following objectives:

- Design an assessment plan for the online foundation surveying-geomatics course that optimizes the application of the concept of "assessment for learning" including assessments and supporting applications.
- Develop a data driven model to measure and validate student learning in the online foundation surveying-geomatics course.
- Estimate the effectiveness of the proposed assessment plan using an experimental design that utilizes data from foundation surveying-geomatics course offerings and student input.
- Propose a method based on pre-course student data and academic performance indicators to characterize online surveying-geomatics students and to predict the future performance of these students in the foundation surveying-geomatics course.

These objectives have stemmed from a need to improve the effectiveness of the education of the online surveying-geomatics student group which is a vital part of educating surveying professionals for the 21st Century. Since this student group provides a substantial percentage of the surveying-geomatics professionals that are necessary for land boundary determination and construction layout functions in The State of Georgia, their success is vital for a thriving balanced economy. (Georgia S.O.S. - Georgia Board of Professional Engineers & Land

Surveyors. (n.d.). Retrieved from http://sos.ga.gov/index.php/licensing/plb/22) Thus, to achieve the required research objectives, the following topics within the existing literature were examined:

- Online Surveying-Geomatics Educational Needs
- Surveying-Geomatics Pedagogy, Platforms and Teaching Approaches
- Assessment Applications in Online Learning in Surveying-Geomatics
- Surveying-Geomatics Online student characterization
- Statistics and Analysis of Student Characterization and Student Academic Performance
- Surveying Licensure Exams and Student Academic Performance

In summary, this literature review provides a synthesis of the components necessary to support the development and completion of the required research objectives.

2.1 Online Surveying-Geomatics Educational Needs

It can be said that the surveying–geomatics (s-g) student's educational needs vary with the viewpoint of the individual stakeholder. The most influential of these stakeholders include professional societies, accreditation agencies, license exam preparers, government bodies, educational institutions and the s-g students. For purposes of background and to illustrate how this research subject ties into s-g student's educational requirements, the following summations of the stakeholder inputs were provided.

2.1.1 Professional Societies

Professional societies in surveying-geomatics occur at both the national level and the state level. This hierarchy is good in that it both addresses local needs as well as facilitating educational views being passed between individual states and across the United States (U.S.). The influence of these state and national societies is discussed below.

2.1.1.1 National Societies

Currently in the United States, the primary s-g society at the national level is the National Society of Professional Surveyors (NSPS). Other special societies include the Surveying Engineering division of the American Society of Civil Engineering, the International Federation of Surveyors (FIG), American Society of Photogrammetry and Remote Sensing (ASPRS) and the Cartography and the Geographic Information Society (CAGIS). All of these societies are concerned with the future of the s-g professions and their related educational requirements. Recently, due to the pressures created by the decreasing numbers of surveying professionals and the encroachment from other professionals from related emerging technologies, the NSPS has updated the surveying body of knowledge (*sbok*) (Greenfield, 2011) required for surveying-geomatics in order to clarify the scope of s-g. The *sbok* by NSPS was developed at the macro level and the micro level. At the macro level, the *sbok* "consists of general education and surveying specific education. Mathematics, statistics, base science, humanities, management, communication and general laws and ethics comprise the educational areas that underlie any successful practice of surveying." (Greenfield, 2011) "This macro-level of s-g is based on eleven outcomes required by Accrediting Board of Engineering and Technology (ABET), plus four additional outcomes that are specific to surveying." (Greenfield, 2011) In addition, ABET requires that the surveying student develop "at least one in-depth specialty in surveying law, positioning, GIS, image-based mapping, land development, or other." (Greenfield, 2011) In order to provide the necessary education containing the appropriate components of the updated *sbok*, it will be necessary "to institute a minimum education of a four-year baccalaureate degree in surveying for all future surveying professionals." (Greenfield and Potts, 2008) The newly defined *sbok* was expanded for better clarification of the s-g professional scope as discussed in the following micro-level areas of the *sbok*:

2.1.1.1.1NSPS Surveying Body of Knowledge-Legal

The legal body of knowledge stresses the importance of surveying and the profession's authority to determine boundaries as defined by administrative, legislative and local legal systems. The newly presented legal body of knowledge emphasizes that "knowledge of the law is not only significant but is a crucial element of the overall *sbok*. Of all of the activities that fall under the umbrella of "surveying." The surveyor's interaction with the law and how the law relates to property rights-specifically property rights associated with the location of boundaries is the only justification for requiring surveyors to be licensed under the vast majority of jurisdictions, if not all of them." (Lathrop and Lucas, 2011) The new legal *sbok* definition emphasizes the breadth and depth of the knowledge required even at the core level which is necessary for all surveyors. As such, it is obvious that the necessary legal education for a surveyor cannot be contained in a single three hour college course and thus, the newly summarized legal body of knowledge increases the educational compression of college courses currently being taught. (Lathrop and Lucas, 2011)

2.1.1.1.2 NSPS Surveying Body of Knowledge-Land Stewardship

While the concept of surveyors practicing a stewardship role in conjunction with real property is not foreign to most surveyors, the quantification of the surveyor's stewardship functions may be new to some surveyors. In this *sbok*, the protection of the natural and human environments requires the practice of stewardship in "professional functions which include land use, site development, and resource management in the natural and social environment…"

(Lathrop, 2011) The general knowledge areas required to support these stewardship functions include: communication skills; site design and resource management; site restraints and assets; and project organization, management and administration. (Lathrop, 2011) As with the legal *sbok*, the Land Stewardship body of knowledge adds to the educational compression of college courses currently being taught.

2.1.1.1.3 NSPS Surveying Body of Knowledge-Positioning

The content of NSPS's *sbok* for positioning may be the specialty *sbok* with which land surveyors associate the most directly. The knowledge areas (first level breakdown) for positioning include: measurements; physical laws; solid geometry and other mathematical tools; computer tools; error estimation, error propagation, least squares adjustment and other tools; standards and specifications; information management; communication principles; and economic, legal and business concepts. (Pavia, 2011) Most of these knowledge areas are covered at least to some extent in the FSG course which is the one of the primary activity subjects of this research. The impact of positioning tools such as Global Positioning Systems (GPS), the uses of laser assisted equipment for scanning & other purposes plus the applications of Information Technology (IT) in voice and data communications have expanded the amount of knowledge required by s-g students and professionals. (Pavia, 2011) Thus, this expansion applies to the scope of the FSG course and makes the understanding of the mathematics and physics even more important. Student learning becomes more critical with the expansion of subject coverage and the increasing daily demands of the students especially online students.

2.1.1.1.4 NSPS Surveying Body of Knowledge-GIS

The Geographical Information Systems (GIS) *sbok* is probably the most controversial since it is a relatively new addition to the s-g professional's toolbox and creates an overlap of responsibilities between the s-g professional and the GIS professional. In this NSPS *sbok,* the knowledge areas have been extracted as a subset of the GIS *sbok* which was developed by Association of American Geographers (AAG) and the University Consortium for Geographic information Science (UCGIS). (Greenfield, 2011) The knowledge areas for s-g professionals in GIS include: conceptual foundations; data mining; design aspects; data manipulation; analytical methods; cartography and visualization; legal and ethical aspects of GIS and management & organizational aspects. (Greenfield, 2011) Since "the minimal level of GIS knowledge a surveyor must master should enable him/her to routinely use basic GIS technology", this a subject that is introduced in the FSG course and adds to the expansion of education requirements of the FSG student. (Greenfield, 2011)

2.1.1.1.5 NSPS Surveying Body of Knowledge-Imaging

For the s-g professional, "imaging refers to the capturing a scene by means of light intensities, Image products are often 2D geometric projections of a 3D scene." "The formal name that goes with the subject of imaging, sensor calibration and 3D scene reconstruction is Photogrammetry." (Bethel, 2011) The imaging knowledge areas include cameras and photography; radiometry, detection and sensing; frame geometry; image measurements; stereoscopy and parallax; mathematical modeling and analytical photogrammetry. Additionally, computer vision; estimation, adjustment, statistics and error propagation; stereo resolution; rectification and resampling; mapping and cartography; topography and digital elevation modeling; digital photogrammetry; project planning; close-range photogrammetry; satellite photogrammetry; remote sensing; and active sensing with LIDAR are included. (Bethel, 2011) While photogrammetry has been a subject of course coverage in surveying for many years, the application of IT and digital photography has greatly expanded the scope of the imaging *sbok* and thus certificate programs & degree programs in s-g have had difficulty in keeping up with the knowledge and skill expansion in this area. (Bethel, 2011)

2.1.1.1.6 Other concerns over ever an expanding Surveying Body of Knowledge

While some educators and practitioners recognize the almost exploding geospatial industry and they recognize that geospatial professionals make a significant contribution to society in terms of information unavailable to us in the past, there is underlying concern for the control and administration of the geospatial data. “Who is in responsible (can be held accountable?) for the accuracy, appropriateness and integrity of those data?” (Burkholder, 2008) Questions that are being asked include: What is the role of the GIS professional in producing and distributing the new geospatial data?; Can GIS be considered just a tool?; and How can engineers and surveyors work together to take advantage of this new resource? (Burkholder, 2008) Another factor that enters into the education arena is the idea that truly understanding many of the new measurement technologies in s-g may require an education more in line with engineering. Thus, the question is asked: Should we move s-g education more toward that required by ABET for engineering instead of Applied Science? (Soler, 2010) Others argue that surveying education should strive for balance (or appropriate distribution) between training and theory. The worry is that the current balance leans toward tools and equipment. The challenge for educators is how to use technology to support the teaching theoretical concepts remembering that the need for technical training is necessary for the growth of the profession. (Burtch, 2005)

While many factors emphasize the challenges before s-g educator and practitioners all is not gloomy. As Dr. Paul R. Wolf indicates while discussing new geospatial technologies, “Never before have so many modern high-speed technologies been available for performing the work of collecting and processing data about planet earth. Never before has civilization demanded so much information for making decisions in planning and designing proposed projects, managing available natural resources and preserving the environment. Concurrent with these developments, geographical information systems have emerged and matured. These systems enable vast quantities of environmental data to be integrated and analyzed to render the information needed for decision making. All of these factors collectively have created great opportunity for a rebirth in surveying mapping." (Wolf, 2002)

Moving to the cartographic world (CAGIS), which interfaces with s-g, we identify that cartographers in education have noted a frustration in declining student numbers and the lack of practice of cartographic principles in GIS map making. The Cartographic Universities in the UK are emphasizing GIS as a mapping tool. (Education, *The Cartographic Journal*, 2011) David Forrest points out the decline in funding for higher education in Cartography in the UK. He states that "Financial allocations to universities have generally not kept pace with inflation…" Education in Cartography has diminished while GIS applications continue to grow. "Cartographers have long complained about the poor quality of the output from GIS, which generally today is not due to a limitation of the GIS itself, but due to lack of understanding of cartographic principles by their users." (Forrest, 2003) Cartographers worry about the presentation in mapping. As Kenneth Field expressed his concern, "There remains a need for people educated in Cartography particularly since there is an increasing need for people to be able present data in a map effectively. The decline in cartographic education is worrying and the evidence is startling." (Field, 2005)

2.1.1.2 State Societies

States' s-g societies are concerned about the requirements of education for s-g professionals as well. State societies typically follow the lead of the NSPS, SED-ASCE and

ABET in looking at the educational requirements for s-g professionals. However, many state societies are stymied by the specific legal controls for licensure exercised in state government. (NCEES, Benefits of a Four-Year Degree for Surveying Licensure, 2011) As an example, slightly more than half of the states within the US require a four year degree for licensure (NCEES, Benefits of a Four-Year Degree for Surveying Licensure, 2011). When states without the four year requirement try to get legislation passed to require the four year degree, they may be thwarted by politicians who are apparently misinformed about the expansion of s-g technology and the need for a four degree. As an example in the state of Georgia, the Surveying and Mapping Society of Georgia (SAMSOG) has proposed legislation to require the four-year degree on three different occasions. (State of Georgia - General Assembly Legislation. (n.d.). Retrieved from http://www.legis.ga.gov/en-US/default.aspx) On two of these occasions, the Governor of the state vetoed the legislation and more recently on the third occasion, the legislation was not allowed to come up for a vote in the House of Representatives. A question may be asked: What's at stake? The significance of the four year degree is known: Four year degree holders were nine times more likely to pass the LS Exam than Associate degree holders and 20 – 100 times more likely to pass than those with little or no formal education. (Crossfield, 2005)

The licensure framework established by state government is very important since it controls the educational requirements for licensure as an s-g professional. When educational requirements are kept at a minimum by the state, future professionals especially those that are already working in the field are driven to the shortest path to get licensure and their desire to get a comprehensive education in s-g may not be their top priority. When, college and university administrators experience this situation, they are not inclined toward program expansion or even program maintenance. (Barnes, 2009)

2.1.2 Accrediting Agencies

While all colleges in the U.S. have regional accreditation agencies which they are responsible to in order to maintain creditability, as an additional measure, many s-g and engineering programs work with the Accreditation Board of Engineering and Technology (ABET) to insure that standards of excellence are met. (ABET-Criteria for Accrediting Applied Science Programs. (n.d.). Retrieved from http://www.abet.org) In s-g, ABET reviews program criteria covering curriculum and faculty qualifications for proficiency (in Baccalaureate Programs) or competency (in Associate Level Programs) in the following areas: boundary and /or land Surveying; geographic and/or land information systems; photogrammetry; mapping and geodesy; remote sensing; and other related areas. (ABET-Criteria for Accrediting Applied Science Programs. (n.d.). Retrieved from http://www.abet.org) ABET evaluates the student outcomes which are referenced in the NSPS *sbok* documentation listed above.

It can be summarized that surveying-geomatics in the United States is taught at three levels according to the three ABET Accrediting committees, Engineering Accreditation Commission (EAC), Applied Science Accreditation Commission (ASAC) and the Technical Accreditation Commission (TAC). In surveying –geomatics, these commissions deal with Bachelor's Programs at the EAC & ASAC levels and Associate Degrees at the TAC level. (ABET- ASAC – EAC - TAC. (n.d.). Retrieved from http://www.abet.org) In conjunction with the ASAC accredited programs, it is felt by some s-g professionals that ABET by introducing ASAC programs in surveying has allowed for dilution of the surveying education. (ASAC program are typically less rigorous that Surveying Engineering Programs.) It is argued that understanding new measurement technologies is more in line with the education in surveying engineering programs. Thus, it is suggested that education professionals should invigorate the surveying engineering profession for the benefit of future generations and institute the four year degree for licensure. (Soler, 2010)

With the expansion of the requirements of knowledge and skills required by the s-g student, ABET is keenly aware of the pressures placed on curriculums and required courses. Looking at distance education as a viable option in education, in 2000, ABET published a viewpoint on the Distance Education which allowed for the pilot studies of the accreditation of distance programs. “ABET should develop processes and procedures for accreditation of distance learning programs through participation in early pilot studies of such programs. This process should contain specific metrics for evaluating the effectiveness of distance education.” (ABET-Viewpoints-IAC. 2000. Retrieved from http://www.abet.org) Currently, ABET lists at least nine fully online programs that have been accredited. (ABET - Online Programs. (n.d.). Retrieved from http://www.abet.org/online-programs/) “ABET evaluates programs that use a variety of delivery methods: on-site instruction, online instruction, and those having components of both methods. The programs are evaluated against the same standards regardless of delivery method.” (ABET - Online Programs. (n.d.). Retrieved from http://www.abet.org/online-programs/)

2.1.3 License Exam Preparers

In the United States, the majority of the licensure exams for s-g professionals are prepared by the National Council of Examiners for Engineering and Surveying (NCEES) in Clemson, SC. This group is charged to prepare, administer or assist in administering the Fundamentals of Surveying Exam (FS) and the Professional Surveying Exam (PS) which are required for professional licensure. The scope of these two exams runs in parallel to the educational scope for s-g applicants as provided by NSPS and was discussed in the above sections. The NCEES defines the Professional Surveyor as being “educated in the basic principles of mathematics, the related physical and applied sciences and the relevant requirements of the law for adequate evidence and all requisite to the surveying of real property.” (NCEES Model Law, 2012) The NCEES goes on to define the Practice of surveying to include “professional services using such sciences as mathematics, geodesy and photogrammetry…” (NCESS Model Law, 2012)

Recently, beginning with the January 2014 exam, the NCEES has computerized the FS exam and reduced the number of questions from 170 to 110 & the number of hours allowed from eight hours to six hours. Subject matter and question coverage changes were very minor. LiDAR and Database concepts & design were notable new additions in comparison to the old exam. Likewise, in 2013, the NCEES made some subtle changes in subject area coverage to the PS exam but NCEES did not change the number of hours for the exam. Some of the new items appearing in the new exam include: state/local statutes, laws rules & regulations; monumentation laws & ordinances; Federal Geographic Data Committee (FGDC) standards (digital mapping); activities, background, and skills of professions (e.g., engineers, lawyers, architects, planners); and hydrographic surveys, condominium surveys, subdivision surveys and record drawing (as-built) surveys. (NCEES – Website. (n.d.). Retrieved from http://ncees.org/) While these changes seem small, any additional coverage adds to the curriculum compression already experienced at all s-g program levels.

2.1.4 Government Bodies

While U.S. lands may require special treatment (Federal Land System) in many s-g applications, the most influential government body influencing the educational of s-g students is the state government. Each state has their own governmental structure for dealing with licensure & education of s-g professionals and these structures may vary considerably. (Purcell & Butler, 2004) However, it is not uncommon to have a legislature writing laws that determine the legal practice of s-g, and a licensing board writing rules to interpret laws and writing policies to support rules and laws. Also, in most states, the governor has the power to veto laws introduced by the legislature. With these factors in mind, it is easy to see that there is wide diversity in the licensing requirements (and thus the educational requirements) in the United States even though the services (as indicated by NSPS) provided by the s-g professional are typically necessary in all of the states.

Some of the states have laws, rules and policies in effect today that have not changed in the last 20 years. (Purcell & Butler, 2004) Thus, there are many educational requirements and skills that are missing from the laws, rules & policies and this omission can have a negative impact on the education provided to future s-g professionals. Students and future practitioners will say: Why should I study a subject in s-g that is not required by law, rule or policy?

2.1.5 Educational Institutions

While technology requiring additional knowledge and skill is advancing at tremendous speed, s-g instructors and administrators are besieged with numerous problems impacting program growth and /or survival. Internal institutional pressures, lack of students and lack of future instructors to go along with the impact of a poor national economy are but a few of the problems that s-g educators are facing. In a study of five leading geomatics institutions, Dr.

Grenville Barnes identified the problems of moving geomatics departments around within different colleges & departments (changing from stand-alone departments back to engineering or engineering technology departments), disconnecting undergraduate programs from graduate programs and dismantling programs due to poor enrollment at the undergraduate and graduate levels. “Given the programmatic changes in the major Geomatics Programs in the U.S... it is clear that we have reached a crossroads in geomatics education.” (Barnes, 2009)

The problem of recruiting new students for colleges offering s-g programs has not gone away either. Even with inclusion of courses and modified programs that provide information and skills required in the GIS world, surveying student numbers are not increasing. It is suggested by many that the s-g profession still suffers from “the low esteem the surveying profession commands among the general public.” (Barnes, 2009) Future studies identifying the market & financial potential of the addition of the acquisition & analysis of geospatial data by s-g professionals should be forthcoming to help guide future s-g candidates toward what should be a very dynamic profession in the future.

The problem of finding new faculty trained at the graduate level is another problem which has evolved from the de-emphasis of surveying in the U.S. Very few students are going into graduate school in s-g. With most of the graduate programs emphasizing geospatial science and applications, new instructors may need to come from different fields. (Barnes, 2009)

2.1.6 Surveying-Geomatics Students

With all of the stakeholder challenges discussed up to this point, we must say that no challenge is more important than meeting the needs of the s-g student. In order to evaluate student needs, we can broadly classify s-g students as traditional students (face to face) generally attending well established programs or place-bound students gaining access to s-g education via distance learning/online platforms. Given the low numbers of s-g students overall, we must say that both of these groups are absolutely necessary for the survival of the profession.

Traditional s-g students are typically younger than place-bound students and traditional students have the advantage of recently coming from an academic environment. The traditional s-g students generally have the typical millennial student characteristics which has both its advantages and disadvantages. (Potts, 2010) Traditional students may more easily adapt to the skill set required of new technology and may possess a more efficient ability to search for information. However, their study habits and work ethic may not be as strong as the place-bound student. Instructors of traditional students need to be aware of all of the *sbok* requirements and creatively deal with curriculum and course compression created by expanding technology.

Place-bound s-g students are generally several years removed from college and they are typically older than their traditional counterparts. However, they are usually already working in the s-g field and as such may have had the opportunity to re-acquaint themselves with some of the math required in the discipline. Place-bound students tend to have a stronger work ethic since most of them are acutely aware of the limited amount of time that they have to assimilate their coursework. Place-bound student instructors need to work creatively as indicated above and must also be aware of the extreme time constraints of the place-bound student.

There are many commonalities between both groups. Generational legacies frequently occur in both groups of students. At the undergraduate level, it can be said that both groups of students put the completion of the minimum coursework necessary for licensure as a top priority. Students are not concerned so much about the *sbok* approach to education which gets back to the importance of the legal aspects of what is required to become licensed as a surveyor in a particular state.

2.1.7 Surveying-Geomatics Education at a Crossroads: Where do we go from here?

While it can be seen that the scope of s-g has certainly expanded dramatically in the last 15 years, what have s-g education programs done to facilitate this expansion in scope? The ability to react positively to the increased education requirements in s-g has been neutralized by the lack of funding and support at most colleges and universities teaching s-g. (Barnes, 2009) Administrators view the small numbers of students going into s-g as a sign of reduced need for s-g programs. Bachelor programs and Graduate programs have been moved around within the institution structure and faculty members are not being replaced as they retire. (Barnes, 2009) While these challenges are very difficult to deal with at the instructor level, there are things that can be done at the classroom level. As an example, in this research, online student learning in the foundation surveying-geomatics course will be addressed.

Student learning in FSG courses such as Surveying I or Plane Surveying (SURV 2501 at Middle Georgia State College (MGSC)) is essential to bridge from geometric and trigonometric concepts into dimension measurement, construction layout and positioning. It has been determined that at least one-third of the content of the National Council of Examiners of Engineering and Surveying (NCEES) licensure exams contains questions from topics covered in these foundation surveying-geomatics courses. (NCEES – Website. (n.d.). Retrieved from http://ncees.org/) In order to understand the relationship of the student’s performance in the FSG course to the student’s pre-course academic performance, characterization of the student is necessary. This characterization should include such factors as pre-course testing, high school performance and geospatial demographics including socio-economic factors. (Besterfield-Sacre, et al, 1997)

Finally, since the successful completion of the Fundamentals of Surveying (FS) and Professional Surveying (PS) exams (for surveying licensure) is directly dependent on the student learning obtained in the FSG course, it is essential that student performance in this course is well defined in terms of assessments, that these assessments are evaluated properly in terms of student learning and that the relationship between pre-course preparation and the foundation course performance is understood through the application of statistical methods.

2.2 Surveying-Geomatics Pedagogy, Platforms and Teaching Approaches

2.2.1 Introduction

Before the proliferation of computing capabilities, s-g programs and courses followed closely with the basic trigonometry/geometry, legal requirements and surveying equipment skill set of the day. Textbooks were used extensively and the surveyors education was built on a "bottom – up" pedagogy. Many times instructors relied on the heuristics of others and their own experience in order to establish what was important in an s-g course. With the application of computing, not only has the technology evolved tremendously but the ability to change pedagogy, platforms and teaching approaches has been made available to s-g instructors.

2.2.2 Pedagogy

As stated above, the s-g course pedagogy in a face to face course is traditionally a "bottom-up" instructor-centered pedagogy where new material builds on old material in a progressive order. Math and science courses support freshman & sophomore level s-g courses and freshman & sophomore level s-g courses support junior & senior level s-g courses. Often projects and real-world problems were not introduced until very late in a student's program as a capstone project or other application. For some institutions, this type of pedagogy was continued in online courses due to time constraints and the lack of available training for online courseware tools.

With this older type of pedagogy, the addition of new materials and lab requirements resulting from new technologies creates a compression of learning which is often "overwhelming to inexperienced students." (Shortis, et al., 2004) "Students with relatively poor preparation in mathematics are clearly disadvantaged, and inevitably have much greater difficulty understanding design concepts that are based on principles derived from geometry and statistical theory." (Shortis, Leahy, Ogleby, Kealy and Ellis, 2004) The place of the traditional lecture in geomatics is also being questioned. Instructors are critical of the status given to lectures. "Nowadays, with printing and even more with the internet, the transmission of knowledge is no longer limited by physical reproduction process and mechanisms. Knowledge is everywhere and anytime." (Roy, 2012)

Changes in pedagogy are being suggested. "Pedagogy must be dynamic and facilitating knowledge by working on contents (and not merely presenting contents)." (Roy, 2012) It is suggested that teaching can emphasize problem solving or case studies in a "top-down" type approach in order to facilitate course compression and the lack of the students' ability to synthesize knowledge and incorporate new skills. Additionally, it is recognized that there will need to be "a change in the culture of learning by the students, and delivery by academic staff." (Shortis, Leahy, Ogleby, Kealy and Ellis, 2004) It is suggested that multimedia materials will provide links between geometry, measurement and the use of instruments. Simulations are proposed to reinforce spatial relationships and field procedures. Other institutions are looking at adding more "real surveying projects to implement theoretical knowledge in real-life situations."

(Wissa and Bajracharya, 2007) The creation of such drastic changes in pedagogy requires a great deal of resources & extensive work by the instructor to ensure of coverage of materials and to maintain student learning in a way that will prepare the student for the FS and PS exams since these tests may serve as the ultimate yardstick for s-g teaching and student learning. (Potts, 2010)

2.2.3 Platforms

With the advent of the personal computer and numerous other IT advances, the presentation of s-g education can be done in numerous forms which support the capabilities and constraints of the student. We still have the face-to-face presentation platform as in traditional courses and now we have online computing platforms which allow for asynchronous and synchronous online presentation and other combinations including hybrid courses which utilize a combination of face-to-face and online presentation. These changes in educational technology are still in their infancy, and educators would probably agree that many more changes are expected. (Levin, Liimakka and Leick, 2010)

Common online course management platforms include Blackboard®, Desire2Learn® (D2L), Moodle® and others. All of these platforms have IT tools (email, discussions, course news, quiz tools, chat tools, and course information structure & data tools) to support the teaching and learning of the course material. Generally, the selection of the platform is done at a University or University System level and the individual instructor has little or no input into the selection of the platform. Consequently, the instructor is left with the task of learning a system, making decisions on which tools to utilize, determining how material will be put on the platform and implementing management of the software for the specific course. Support for the instructor varies with the individual institution. However, typically, basic training of the most common features that come with the platform software may be provided as a tutorial. The fact that the platform selection can change from time to time based on cost, capabilities and administration preferences, requires the instructor to maintain some degree of flexibility in how he or she uses the platform.

Evaluation of the general effectiveness of online platforms on student learning is limited. A 2010 Meta-analysis by the U.S. Department of Education (USDOE) indicates that "on-average students in online learning conditions performed moderately better than those receiving face-to-face instruction." (Means et al, 2010) While this meta-analysis only included 50 study effects, there were 43 effects from older learners. Reviewing the individual studies (Purely Online versus Face-to-Face) with a science-math-technology subject, seven studies showed a positive effect size ranging from small to large while two studies showed a negative effect size (Means et al, 2010). Reviewing the individual studies (Blended versus Face-to-Face) with a science-math-technology subject, seven studies showed a positive effect size ranging from small to large while two studies showed a negative effect size. While the USDOE study produced mostly tentative results, certain indicators were discussed including: inclusion of more media may not enhance learning if content is controlled, incorporating mechanisms that promote student reflection may be helpful, providing multiple choice quizzes did not appear to enhance online learning, individualizing online learning by dynamic content generation was found to be effective in certain cases and guiding "the online interactions of group of learners was less successful than the use of mechanisms to prompt reflection and self-assessment." (Means et al, 2010)

2.2.4 Teaching Approaches

Teaching approaches vary with the institution. Face-to-face s-g programs typically include teaching strategies that reflect the education of the instructor and may include components such as recognition (identifying learner difficulties), complexity building (step-wise increases in problem complexity), contextualizing (using examples to grasp the subject matter and make cognitive connections), representation (illustrations to aid visualization of concepts) and interaction (creating an interactive learning environment). (Potts, 2010) To improve student interaction, it is suggested that web-interfacing may be utilized especially for millennial students. (Potts, 2010)

Looking at s-g online teaching approaches at the beginning of this research, Michigan Technological University (MTU), Great Basin College and Middle Georgia State College (MGSC) were identified as offering undergraduate courses with some degree of utilization of online platforms. It is expected that several other institutions are now offering or planning online courses as well. At MTU, courses are managed with WebCT® where video streams are maintained for class viewing. Exams are monitored at a site by a site coordinator. Answers to assignments, quizzes and exams are posted and graded assignments are also returned to students. (Wijayratne, 2005) Lab practicals requiring software are facilitated by a Citrix® web server. Labs with field components are conducted on campus on Friday/Saturday weekend. (Wijayratne, 2005) The Great Basin College Geomatics Program is structured to allow students to work while gaining coursework toward the four-year degree in the evenings and over the Internet. (Great Basin College Website. (n.d.). Retrieved from http://www.gbcnv.edu/)

At MGSC, courses are delivered online utilizing Desire2Learn® (formerly using GeorgiaView (Blackboard®)). Unit Quizzes are not monitored and in-state students must travel to the campus for final exams while out-of-state students may use a proctor for the final exam. Currently, labs are not required since the students typically are working surveyors and specific lab requirements are not part of state licensure requirements. (Georgia S.O.S.- Georgia Board of Professional Engineers & Land Surveyors. (n.d.). Retrieved from http://sos.ga.gov/index.php/licensing/plb/22) As can be expected with the introduction of new teaching technology, there are questions and concerns. The effectiveness of online learning has been questioned but only progressive implementation and time will reveal the results. In the case of s-g, online course offerings make education happen where it might not otherwise happen. Additionally, greater opportunities are made available including: students ability to learn on their own time, students are not affected by commuting traffic, students with basic course knowledge are not forced to waste time on duplication, students can learn at their own pace reducing boredom and instructors can provide a greater breadth and depth of materials. (Elithorp, 2007) The MTU program (evolving from the oldest distance learning s-g program) which is an ABET accredited hybrid program produces graduates with high pass rates on the FS and PS exams. (Wijayratne, 2005) Some of the recommendations cited from their program experience are as follows:

- The quality of student support services is as important as the quality of the education that the student receives.
- The program management has to be handled responsibly with the appropriate College-Division-Department being responsible for academic issues.
- Non-academic issues require sensitivity to the special student needs and a dedicated office should be available to accommodate this need.
- Timely maintenance of the s-g program information webpage must be implemented.
- Timely responses to information requests should be insured.
- Having a student friendly method to process admission applications and accept fees is required.

- Having a strong working relationship with the admissions office to evaluate the eligibility of students is necessary.
- Having a student friendly system to handle course enrollment/registration and semester billing is essential.
- It is suggested that the program have a dedicated program advisor with the following responsibilities:
    - Coordination required for awarding transfer credit
    - Awarding placement credits & conducting or assigning tests to assess required knowledge
    - Setting up degree plans and course scheduling
    - Providing Advising/Mentoring
    - Following-up & submitting updates on the student's progress
- In course development, the instructor is responsible for the preparation of course content, course notes, guidebooks and other course related materials. It is suggested that guidebooks are helpful for online students, with or without textbooks.
- The instructor should follow the course content and provide helpful items for students including:
    - Directions for direct access to the instructor
    - Arrangements for direct interaction of the student with the class
    - Chat rooms
    - Providing access to additional education materials

(It was noted that it may be helpful for the instructor to teach in front of live audience when possible.) (Wijayratne, 2005)

A review of the International Federation of Surveyors' (FIG) study entitled "Enhancing Surveying Education through e-Learning" indicates that effective e-learning (online learning) requires the development of new courseware that is more time consuming than giving a series of lectures & practical sessions and requires technical & pedagogical expertise. The study goes on to cite that communications (between student and instructor) must be open and instructors must be kept aware of technologies used in e-learning. A complete buy-in by administrators, instructors and students is required. (Frank, Mansberger, Car, Petch and Frunzi, 2010)

2.3 Assessment Applications in Online Learning in Surveying-Geomatics

2.3.1 Introduction

Assessment is the tool that allows the student learning in surveying-geomatics to be measured. Assessment can be defined as the process of testing, appraising, and evaluating growth, products and processes or changes in these elements using formal and informal techniques. (McKinny, 2011) Course assessment can be framed against desired program student learning outcomes which are established from accreditation and licensing test requirements. In the case of s-g, these program student learning outcomes can be developed by looking at the ABET accreditation requirements and NCEES examination coverage which were shown in documentation and are provided in Appendix A. Dr. Stephen Frank cites that "ABET encourages the use of direct measurements of outcomes, for example by examination question or student project, as opposed to indirect measures such as interviews or surveys." (Frank, 2008) Additionally, Seybert has proposed a method that ties program assessment to course assessment in conjunction with student learning outcomes that are based on applicable ABET criteria. This method also provides for feedback to instructors and students to make adjustments that may be applied in the future to improve student performance. “Assessment of course outcomes can be used to support the assessment of achievement of program outcomes as well as the quality of instruction in the classroom.” (Seybert, 2008)

It is recognized that there is skepticism regarding curriculum transformations and assessment changes such as those proposed in this research. “Detractors of curriculum transformation and multimedia techniques often cite the lack of hard evidence of improvement (of student learning) as a failure of these methods to improve teaching and learning.” (Shortis, Leahy, Ogleby, Keahy and Ellis, 2004) However, in this research, newer combinations of methods, assessment types, supporting methods and normalization of assessment data are proposed to provide a framework to analyze student learning at the course level.

2.3.2 Definitions

The definitions chosen to support the development of assessment in s-g include the following:

“Assessment”: “Simply put, assessment is a process used for improving quality. Assessment is critical for life-long learning skills and elevating performance in diverse contexts.” (Baehr and Beyerlein, 2007)

“Assessment for Learning”: In this approach, the student is provided assessments during the course which allow for the student to demonstrate their learning before the end of the course. For purposes of this research, diagnostic assessment, evaluation, feedback, guidance and performance assessment have been chosen as the tools of application. (McKinny, 2011)

Assessment Method: A process involving a structured situation that includes samples of particular characteristics or behaviors that result in a numerical or narrative score. (Mertler, 2003)

"Assessment of Learning": In the case of the FSG course, this assessment is a determination of a student's performance (course grade) where the summative determination is made at the end of the course when the course work is complete and the student has no ability to show improvement. Thus, if the performance is unsatisfactory, the course must be repeated. (McKinny, 2011)

Assessment System: All of the systematic methods and procedures that are used to obtain information about behaviors and upon which educational decisions are based. (Mertler, 2003) Wicks defines an assessment system as " a set of structured activities in which participants use clear criteria to measure their performance, interpret findings, take actions to improve quality and document these for future or third party use." (Wicks, 2007)

Authentic Assessments: Assessment that measure a student's ability to apply learned skills to real-life situations. (McKinny, 2011)

Diagnostic Assessment: Assessment methods that are used to determine what students already know and can do; designed to identify the nature of specific student difficulties. (Mertler, 2003)

Feedback: Information about what was and was not accomplished (in an assessment), given a specific goal. (Wiggins, 2008)

Foundation surveying-geomatics course (FSG): This course introduces the study of the theory and practice of plane surveying using the traditional methods of surveying, including pacing, taping, and the use of the compass, transit (theodolite-total station), and level. Thus, the course represents a bridge for students from the strictly mathematical concepts of algebra and trigonometry to more complex concepts and applications which are utilized throughout the surveying-geomatics curriculum. Newgren states that "the common denominator in the foundations course is the intent to provide the basis for a much broader experience." (Newgren, 2007)

Guidance: Gives future direction or what I should do in light of what just happened. It tells the most likely way to achieve the goal or learning target. (Wiggins, 2008)

Performance Assessment: An assessment activity that provides direct observation of student performance; usually an authentic assessment. (Mertler, 2003)

2.3.3 Types of Assessment currently used in Foundation Surveying-Geomatics Courses

In order to understand current course assessment in the FSG course, we must look at how the course has evolved. Many of the existing face-to-face programs and online programs in s-g contain a FSG course (often called Plane Surveying) and an advanced surveying course. These two courses are generally offered as a sequence where the FSG course covers planar surveying and the Advanced Course covers the fundamentals of newer measurement technologies such as GPS and others. The FSG course provides for student learning of horizontal and vertical angular measurements and distance measurements where these measurements are resolved into a horizontal coordinate systems and/or vertical data. Also, in the case of the FSG course, there are many textbooks available that have traditionally been used by instructors. (Examples include: Wolf and Ghilani's *Elementary Surveying An Introduction to Geomati*cs and Kavanagh's *Surveying Principles and Applications.*) These FSG textbooks support a primary purpose of educating future land boundary surveyors. (Land boundary surveying is now considered to be only a part of a broader Geomatics education.) The structure of the FSG course usually follows the progression of the material in the textbook with supporting lectures that introduce and/or emphasize the important concepts within the chapters. In the case of the online FSG course, the textbook is one of the main resources to reinforce student learning. The face-to-face FSG course is often taught with a lab component which contains field exercises that run parallel with the text/course coverage. The online FSG course may or may not require a lab component depending on the student's field experience and/or the requirements of the state law covering professional registration. (Georgia SOS, "Georgia Board of Professional Engineers & Land Surveyors", http://sos.ga.gov/index.php/licensing/plb/22, March 13, 2014)

Since the FSG course requires student learning with both the base knowledge and the skills necessary to solve problems containing mathematical applications, traditional paper and pencil tests were developed as the primary assessments. The application of these assessments instituted an "assessment of learning" approach in that unit quizzes (paper and pencil) were typically presented at intervals with a large portion of the grade being assigned to the summative assessment (Final Exam) at the end of the course. This approach offered the student very little chance for performance recovery if the student performed poorly on the unit assessments. Additionally, a formal assessment plan beyond the minimal grade calculation scheme was typically not provided and thus, the instructor could not help improve student learning during the progression of the course.

As discussed earlier, the typical first generation of online s-g courses was quickly forced into the preselected course presentation platform with very little time allowed for development. The resulting courses included: lectures which were provided as Microsoft Powerpoint® presentations (without voice), suggested study schedules, syllabi, and quizzes/exams hammered out from paper & pencil tests contained in former face-to face classes. Usually the student's course information was grouped with a “File cabinet” structure (Syllabus in one folder, Lectures in another folder, Quizzes in another folder and so on…) that was not necessarily student friendly. As time has passed, the platform tools have improved, instructors have become more online savvy and assessment types have expanded & improved. Some instructors have instituted different approaches including a portfolio approach for their students. All of these progressive steps have been taken but there is little evidence in the literature to support the measurement of improvement in student learning in the online FSG course. Thus, changes are being made and assessments to meet program accreditation are improving but there is no assurance that the student learning in the online FSG course is improving. On a larger scale, if a department is considering an effort to update all of the online s-g courses in a program to support student learning, how can the impact of the effort be estimated? Will the improvement in student learning justify the required time and expense?

2.3.4 “Best Practice” for Assessment in the Online Foundation Surveying-Geomatics Course

One of the most significant steps in providing assessment for online learning which meets the observed need is to develop a plan for assessment. In the case of the online s-g course, the assessment plan has to accommodate the requirements of the online course platform. Additionally, it must be decided how the course will be structured to utilize the platform tools. Thus, it must be decided what is a good time breakdown for the course material. An example might be to break the course down into weeks and with the online structure, one week could be the time allowed for one module within the course structure. Such a division would work well for most working students since they could program their activities to accommodate the online course on a repetitive weekly basis.

Another very important step in developing the assessment plan is to select assessment types and supporting applications which foster student learning. Having knowledge of the characterization of the FSG course student base and a knowledge of the available assessment tools will support a positive selection. Rick Stiggins points out some of the roles for assessment and the way the student sees assessment. These concepts include:

- Assessment and its role in the trajectory of success should be thoroughly understood by the student which means that assessment should be explained early and clearly.
- The student needs to understand examples of good work & bad work and how these examples related to the grading process.
- The student needs to be self-involved in the examination of why answers were wrong and what concepts need to be understood in order to get the correct answers in the future.
- The student's outlook should be focused on future performance which can be improved by applying the information learned from the assessment and not on uncorrectable failure. (Stiggins, 2007)

While aimed at the K-12 audience similar to Stiggins, Chappius provides seven strategies of "Assessment for Learning" as quoted below. Many of these strategies apply to all audiences in student learning including s-g online educators.

- Provide students with a clear and understandable vision of the learning target.
- Use examples and models of strong and weak work.
- Offer regular descriptive feedback.
- Teach students to self-assess and set goals.

- Design lessons to focus on one learning target or aspect of quality at a time.
- Teach students focused revision.
- Engage students in self-reflection and let them keep track of and share their learning. (Chappius, 2009)

Thus, the application of "Assessment of Learning" as currently practiced by institutions may not provide the most supportive approach. It is suggested that an "Assessment for Learning" approach can be incorporated into the assessment plan with the view of maximizing student learning. Creating the plan may require the use of a "Backward Design" which requires that the instructor knows where they are going with the assessment before creation. Wiggins and McTighe suggest that backward design flows from identifying the desired results, determining acceptable evidence and planning of learning experiences and instructions. (Wiggins and McTighe, 2005) It is suggested that an assessment plan have the following: a description of formal and informal assessments that the instructor will use to gauge student learning and adjust teaching as necessary; the type format and purpose of each assessment; a description of what the instructor expects that the assessment will reveal about a student's learning of content, skills and academic language; the feedback to be provided; how the assessment will inform the teaching; and the grading plan. Assessment should require students to produce high quality end products and require students to use higher thinking skills. (McKinny, 2011) Baehr and Beyerlein cite the following "Principles of Quality Assessment: Assessment focuses on improvement not judgment; Assessment focuses on performance, not the performer; Assessment is a process that can improve any level of performance; Assessment feedback depends on who both the assessor and assessee are; Improvement based on assessment feedback is more effective when the assessee seeks assessment; Assessment requires agreed upon criteria; Assessment requires analysis of the observations; Assessment feedback is accepted only when there is mutual trust and respect; Assessment should be used only where there is a strong opportunity for improvement; and Assessment is effective only when the assessee uses the feedback." (Baehr and Beyerlein, 2007)

2.4 Surveying-Geomatics Online Student Characterization

As a point of reference, it should be noted that in the United States, due to the small number of online s-g programs, there is limited research about the characterization of online s-g students. Perhaps the most prolific author in this area, Dr. James A. Elithorp, Jr. will be used extensively to examine this characterization. Inputs from other online s-g instructors will also be examined. Finally, inputs from some freshman engineering student characterizations will be examined as well.

On-line s-g education offerings provide a direct grouping of s-g students which have certain characteristics that may be common across regional states. The characterization of an online student is a strong indicator that the student is constrained by limits of financial resources or limits of time. Thus, the online s-g student is usually identified as a place-bound student and a working student. From a sample of 118 potential students (applying for entrance into the Great Basin College Online Four-Year Degree land Surveying Geomatics Program), Elithorp generated statistics covering "survey work experience, educational attainment and professional status". In the experience category, it was found that "77% of prospective students had more than one year of work experience" and "40% had more than six years of work experience". (Elithorp, 2010) In the educational attainment category, it was shown that "63% of prospective students had an earned degree" (Associate of Applied Science, Associate of Science or Bachelor's Degree) and many of the no-degree applicants had one to two years of college. Also, it was noted “that 27% of the prospective students had a baccalaureate degree”. (Elithorp, 2010) The study’s coverage of professional status indicated that 55% of the prospective students were working survey technicians of whom 22% had earned the certification of Land Surveyor Intern (from NCEES) and 18% were licensed land surveyors. Elithorp’s study indicated that only 17% of the applicants fit the definition of a traditional student. (Elithorp, 2010) Further, Elithorp characterizes the typical online geomatics student as having a “vision which is effectively communicated by having a family member or relative who is a geomatics professional or actually going to work for a geomatics firm.” (Elithorp, 2003)

Wijayratne indicates that “the typical online surveying-geomatic student is mature and self-motivated. They usually take one or two classes and should have good (competent) high school preparation in math, science, English and writing as well as good (competent) computer skills.” (Wijayratne, 2005) Based on 2009 statistics, the typical online s-g student at MGSC is 33 years of age and has an average grade point average of 2.75 out of 4.0. Ninety-four percent of these MGSC students live outside of MGSC’s immediate service area and most have extensive surveying field experience. (MGC-Office of Planning, Assessment and Research, 2011)

Questions that should be asked concerning student characteristics include: What student characteristics are important? and What student characteristics are available? Elithorp cites from Astin (1993) emphasis on the following attributes (Elithorp, 2003):

- A father who is an engineer
- High self-rating of mathematical ability
- SAT math score

- High school grades
- A scientific orientation
- Parents interest and influence

After looking at current literature examining s-g students' traits and characteristics, for support, a focus on classification schemes evolving to characteristic variables in a similar math and science based program, i.e., engineering, is examined. Based on an extensive summary of literature, Li, Swaminathan and Tang have developed a classification system of engineering student characteristics that are divided into groups of external characteristics, cognitive characteristics, affective characteristics and demographic characteristics. External characteristics are split into categories of community characteristics including peer influence, adult influence, curriculum requirements & institutional cultural atmosphere. Cognitive characteristics include academic ability, self-efficacy, and learning attributes. Affective characteristics include attitude, self-confidence, early commitment and motivation. Finally, demographic characteristics include gender, ethnicity, socio-economic status and home & high school background. (Li, Swaiminathan and Tang, 2009)

Identifying cognitive, affective and demographic characteristics as those characteristics being measurable and most directly tied to student learning in engineering, it is desirable to look at these more carefully. For cognitive characteristics, academic ability in terms of strength in math and science may indicate a desire to be admitted to engineering/math related college program and may also indicate the a tendency toward retention and success in these programs. In terms of metrics, SAT Math & verbal scores as well as high school ranking are significant in predicting college GPA. Other cognitive characteristics such as self-efficacy and learning attributes are very important indicators of student learning processes and could be extracted from student surveys. (Li, Swaiminathan and Tang, 2009) Affective characteristics including attitude, self-confidence, early commitment and motivation are very important indicators of student resilience, student retention & future student success and could be extracted from student surveys utilizing a Likert scale. Demographic characteristics include gender, age, ethnicity, socio-economic status and home & high school background (often given in initial application documentation) are also useful in determining relationships between student academic performance and various classifications of these characteristics. (Li, Swaiminathan and Tang, 2009)

Sources of student data which can serve as metrics for student characteristics can come from multiple sources. Student data taken during the admission process and subsequent required data can provide many metrics such as age, gender, standardized test scores, previous college course information and others. Additionally, questions contained in course surveys and evaluations may contain useful metrics. Special surveys administered at specific points in student development and exit/graduation surveys may be useful as well.

2.5 Statistics and Analysis of Student Characterization and Student Academic Performance

2.5.1 Statistics and Analysis of Student Characterization and Academic Performance Prediction

Depending on the student data application, there are typically many techniques available to analyze the student data. Student data assembled in a computer database with statistical functionality is desirable. This assembly will allow the user to perform descriptive statistics and analysis using various methods. Logistic regression, stepwise/hierarchical multiple regression, longitudinal data analysis, covariate adjustment techniques, two-step design, exploratory factor analysis, structural equation modeling, discriminant analysis and clarification tree application are some of the most popular analysis applications in education subjects. (Gay, Mills and Airasian, 2009)

For prediction of performance such as academic performance, generally logistic regression and multiple regression are the most frequently adopted methods. (Li, Swaiminathan and Tang, 2009) Multiple regression is considered to be a valuable procedure used in the analysis of experimental, correlational and causal comparative studies since the procedure examines which variables are related and the degree to which the variables are related. (Gay, Mills and Airasian, 2009) As an example, hierarchical linear regression and logistic regression were used to analyze engineering student success and persistence based on variables of high school rank, SAT scores & university cumulative grade point average. (French, Immekus and Oakes, 2005) At Iowa State University (ISU), statistical analysis and logistic regression methods were used to create a predictive model of engineering student retention. This ISU study utilized a large group of variables with the following variables leading to a high risk of attrition: marital status, African American as race, ACT composite, number of semesters of English in high school and number of semesters of Art in high school. (Moller-Wong and Eide, 1997) Another example occurred with the University of Pittsburg Freshman engineering class where regression models were used to predict attrition and academic performance utilizing such variables as SAT scores, high school rank, number of scholarships received, amount of scholarships received, gender program impact and thirteen attitude & self-assessment measures. (Besterfield-Sacre, Atman and Shumann, 1997)

2.5.2 Analysis of FSG Course Academic Performance resulting from Experimental Research

In the application of experimental design to determine the effect of a change (treatment) in a college course such as the FSG course, the researcher has a choice of experimental methods based on the questions to be answered, the data available and the treatments that can be physically applied. The available experimental design may consist of pre-experimental designs (one-shot case study, one-group pretest-posttest design and static-group comparison), true experimental designs (pre-test/post-test control group design, post-test-only control group design and Solomon four-group design), quasi-experimental designs (nonequivalent control group design, time-series design and counterbalance design) and factorial designs. (Gay, Mills and Airasian, 2009)

An example of a quasi-experimental analysis was provided by Uhumuavbi and Mamudu (Al-Shammari and Mohammad, 2010) as they explored the impact of Programmed Instruction and Demonstration Teaching Methods on secondary student academic performance in science subjects. The specific research questions proposed to be answered included: (1.) “Is there any difference between the performance of students taught using Programmed instruction method and the performance of students taught using Demonstration method?” (2.) “Is there any difference between the performance of male and female students exposed to Demonstration method?” (3.) “Is there any difference between the performance of male and female students exposed to Programmed instruction method?” Utilizing these guiding questions, the researchers established the following hypotheses:

- "H1: There is no significant difference between the performance of students taught using Programmed instruction method and the performance of students taught using Demonstration method."
- "H2: There is no significant difference between the performance of male and female students exposed to Demonstration method."
- "H3: There is no significant difference between the performance of male and female students exposed to Programmed instruction method."

In order to test these hypotheses, the researchers established samples from randomly selected intact classes. Two groups were pre-tested, treated with Programmed Instructional methods (PIM) or Demonstration methods (DEM) and post-tested and the related means of the scores were computed. The pre-test and post-test were analyzed and statistical analysis including descriptive statistics and t-tests for significance was performed.

An example of pre-experimental analysis was provided by Soeiro and Cabral when they studied the impact of changing the University if Porto's existing course assessment system. The impact of the proposed treatment was examined by determining the increase in approved-registered students, in approved-attending students and in the average grade of attending students. Average, standard deviation and significance were calculated for these indicator variables. (Soeiro and Cabral, 2004) As another example of pre-experimental methods, Bamford, Crawford, Croft and Robinson evaluated the impact of a pre-sessional course on the performance of electronic/electrical engineering students in mathematics. A mathematics diagnostics test and a computer based test on matrices were used to measure the impact. (Bamforth, Crawford, Croft and Robinson, 2005)

Finally, an example of experimental analysis was provided by Al-Shammari and Mohammad (Al-Shammari and Mohammad, 2010) where they examined the effect of increasing allocated Academic Learning Time (ALT) on the achievement of college students in Kuwait. In this application, the ALT time is the amount of time spent by students in individual work on actual tasks. The schedules created for the college courses setup the amount of time for various elements of instruction and student work. Thus, the ALT time is established in the schedule which is adjusted to allow for an increase in the ALT as required by the study. College students enrolled in Computer Education Classes were used. The research was defined in two phases where phase 1 had an experimental group of 25 male students and a control group of 25 female students and phase 2 used the male students from the experimental group of phase 1. The phase 2 students were subdivided into an experimental subgroup and a control subgroup. The sample students had completed their third year of college. The instruments of evaluation in both phases were 15 minute pop-quizzes. Thus, the students' answers were coded from the quizzes and data analysis including mean & standard deviation of scores, normalcy evaluation, correlation analysis, and significance was performed. (Al-Shammari and Mohammad, 2010)

2.6 Surveying Licensure Exams and Student Academic Performance

The successful performance of surveying students on the FS exam and the PS exam is one of the ultimate objectives of the s-g student and thus, s-g courses and programs are designed to support this effort. The relationship between student performance along the learning path from pre-FSG course preparation through the final s-g program course and the FS & PS exams should be continuously evaluated. Currently, the NCEES provides analysis of the Fundamentals of Engineering Exam (FE) performances by comparing the exam performance of the college in question with similar colleges. Also, national averages of the performance on the FE exam subjects are also available from NCEES. Currently, this information is not available for the FS and PS exams but it is hoped that the analysis will be provided in the future. (NCEES, 2010)

A useful process to supplement the examination of student performance and FS/PS exam performance is to track the exam passes by applicants as given on the state licensing board website. While this information will not provide a numeric score for the exams, it can be used as an indicator of data confidence since successful exam completion indicates perseverance by the s-g student. This confidence indicator can in turn be used as a grouping variable when studying s-g student performance.

2.7 Literature Review Summary

From the literature review provided above, gaps in the understanding of the challenges and needs of s-g education going forward have been identified. While limited studies have been done to relate individual problems associated with the lack of educational requirements in s-g, there is a need for a comprehensive study of the impacts of not providing the *sbok* as proposed by NSPS to students. Such a study will serve to fill these gaps for educators and administrators. While showing the need for such a study is not the primary purpose of this research, it does serve to emphasize the need for s-g education courses that are effective & efficient and serves the needs of s-g students including online s-g students. The online FSG course is a prime candidate for examination since it serves as the foundation for so many of the subject areas identified in the *sbok*. The *sbok* itself will serve as a general guidance tool as improvements to the online FSG course are proposed in this research.

The existing literature has provided a range of ideas for changes in pedagogy in the FSG course to include problem solving, authentic assessments and case studies. All of these ideas were considered in the development of assessments plans which are part of this research. Course platforms and the tools associated with the platforms were discussed in the literature. The efficient utilization of the available platform tools by the instructor and student was the emphasis of this study. While examining teaching approaches within the literature, several “lessons learned” items were identified and were incorporated in the development of the assessment plan and the course prototype within this research.

The literature provided the basis of the “Assessment for Learning” approach which was incorporated into the assessment plan for the FSG course. This assessment plan provided the framework of assessment and supporting applications which support student learning in the FSG course. The measurement of student learning was facilitated by selected assessments. One of the major contributions of this research was the application and measurement of the impact of the “Assessment for Learning“ approach which was not found in the literature.

The existing studies also support the student characterization included in this study. The information for previous studies provided considerable sources and examples of characteristics that included grouping variables or progressive variables for analysis. Selected variables were studied for correlation with academic performance in an effort to predict new student academic performance in the FSG course. Examples of performance prediction models have been found in the literature but none of these models have been applied to the s-g student. The statistical applications within the published models were helpful in selecting the correct statistical applications that were applied in this research.

CHAPTER 3

DEVELOPMENT OF A NEW ASSESSMENT METHODOLOGY WITH "ASSESSMENT FOR LEARNING"

As indicated previously, this chapter is devoted to explaining the new assessment methodology which represents a new way to train s-g students for the 21st century and which also serves as the treatment described in the experimental portion of this dissertation. In order to do this, we used the knowledge gained from the literature review in the previous chapter to identify the appropriate methodology to be applied in the control section of the research ("assessment of learning"), to identify an ideal implementation for the online FSG course and to explain the best practice changes which include "assessment for learning" that were applied. Finally, we examined the pilot application of the experimental portion of the research as well as the final form of the "assessment for learning" assessment plan. (While this chapter reflects a case study of online s-g education provided at MGSC, it was anticipated that individual components of the "assessment for learning" plan will be applicable to other online s-g course structures.)

3.1 Evaluation of course structure and "assessment of learning" methods as contained in the Online FSG Control Course offerings

In order to order to look at the ideal situation for the FSG course and to make a comparison of student learning resulting from the FSG course offerings containing "assessment of learning" versus "assessment for learning", we need to determine the course structure and "assessment of learning" methods contained in the MGSC course offerings of the FSG course between Spring 2009 and Fall 2011. For future identification, these course offerings will be identified as the control course offerings.

3.1.1 Defining "Assessment of Learning" methods as applied in the Online Control FSG Course Offerings

As defined earlier, "Assessment of Learning" is a determination of a student's performance (course grade) where the summative determination is made at the end of the course when the course work is complete and the student has no ability to show improvement. Thus, if the performance is unsatisfactory, the course must be repeated. (McKinny, 2011) In the control FSG course offerings, the final grade was determined based on the numeric scores of Unit Tests and the Final Exam. There were no repeat offerings of the Unit Tests or the Final Exam. Thus, the final grade was based on heavily weighting the Final Exam score (30%) with much smaller weights being place on the Unit Tests' scores (8.75% each).

3.1.2 Evolution of the Online Control FSG Courses at MGSC

The online Control FSG Course at MGSC was based on the predecessor face-to-face course which was a traditional "bottom-up" instructor-centered course. Thus, the evolution of the online control FSG courses were strongly influenced by these face-to-face courses with regards to course structure and assessment while the platforms changed from nighttime face-to-face presentation to videoconferencing (Georgia Statewide Academic and Medical System-GSAMS) to the Blackboard® platform (online) to GeorgiaView platform (online) and now to the Desire 2 Learn® (D2L) online platform which is the current platform system as of the writing on this research. GeorgiaView was the platform for the online control FSG Courses at MGSC.

The student learning support materials provided in the online control FSG courses included a syllabus, unit study plans and supplemental chapter notes which followed the course textbook. (An example of these materials is provided in Appendix B.) The syllabus was a basic summary of the course with instructor information, material requirements including textbook, (Ghilani, C.D. and Wolf, P.R., 2008) general information, website information, catalog description, student learning objectives, time commitment, grading scale, grade determination, assessment information (unit quizzes and final exam) and the course midterm date. The unit study plan was a brief listing of the chapters contained in the unit and an indication of instructor-identified important sections in the unit. Finally, the supplemental notes were actually a commentary on the sections in the appropriate textbook chapter. It should be noted that since no additional time for preparation and conversion from the traditional course offering to the online control FSG course offerings was allowed, the above student learning support materials did not include figures, equation development, graphics, images, video or audio to supplement the text.

3.1.3 FSG Course Assessment Plan: "Assessment of Learning"

Based on the evaluation and analysis of course materials for the MGSC course offerings of the FSG course between Spring 2009 and Fall 2011, the following assessment plan was developed and summarized in Table 3.1 below along with associated definitions. Note that the assessment and supporting applications are indicative of the "assessment of learning" approach. The study plan and the chapter supplemental notes are helpful to the student in that they reinforce the subjects covered in the unit but they do not necessarily promote critical thinking or self-evaluation. The Unit quizzes and Final Exam will be discussed below.

Table 3.1 FSG Course (SURV 2501) Spring 2009 – Fall 2011 Typical Assessment Matrix

Unit	Description	Study Plan (0%)	Chapter Supplemental Notes (0%)	Unit Quizzes (70% or 8.75% Each)	Final Exam (30%)
1. (ch 1) & (ch2)	Surveying-Broad Intro. What? Units: Sig. Fig. &Field Notes	X	X	X	
2. (ch3)	Errors in Surveying	X	X	X	
3. (ch 4)	Leveling: Theory, Methods & Equipment.	X	X	X	
4. (ch 5) & (ch 6)	Leveling: Field Proceedings & Computations. & Distance Measurement	X	X	X	
5. (ch 7) & (ch 8)	Angles, Azimuths & Bearings. & Total Station Instrument Angle Measurements	X	X	X	
6. (ch 9) & (ch 10)	Traversing & Traverse Computations.	X	X	X	
7. (ch 11) & (ch 12)	Coordinate Geometry in Surveying Calculations & Area Calculations	X	X	X	
8. (ch 13), (ch 14) & (ch 15)	GPS Introduction, GPS-Static & GPS Kinematic	X	X	X	
9. Final Exam	Comprehensive Final Exam				X
Applications of Assessment and supportive applications	**Textbook: *Elementary Surveying An Introduction to Geomatics*, Ghilani & Wolf, 2008, 12th Ed.**	**General Course Guidance**	**Specific Chapter Guidance**	**Unit Assessment**	**Summative Assessment (Control Test)**

Definitions of assessment and supportive applications as included in the "assessment of learning" approach:

Assessment: The process of testing, appraising, and evaluating achievement, growth, products, and processes or changes in these elements using formal and informal techniques. (McKinny, B.J., MSED 7132 Course Notes, 2011)

"Assessment of Learning": In the case of the Foundation Surveying-Geomatics Course (FSGC), this assessment approach provides a determination of a student's performance (course grade) where the summative determination is made at the end of the course when the course work is complete and the student has no ability to show improvement. Thus, if the performance is unsatisfactory, the course must be repeated. (McKinny, B.J., MSED 7132 Course Notes, 2011)

Assessment Method: A process involving a structured situation that includes samples of particular characteristics or behaviors that result in a numerical or narrative score. (Mertler, C.A., Classroom Assessment, 2003)

Unit Assessment: This is a traditional pencil & paper type assessment which measures student learning obtained as obtained from the course module.

Summative Assessment: A formal assessment "administered at the completion of a unit or some major cycle of instruction." (Mertler, C.A., Classroom Assessment, 2003) In this research, the final exam is considered to be the summative assessment.

3.1.3.1 Unit Tests

Since the unit tests serve as the source for the common questions that were used for comparison of the student performance between the control and experimental course offerings later in this study, the questions within the unit tests were examined for classification according to their cognitive levels. (Bloom, B. Blooms's Taxonomy Graph. Accessed May 3, 2014. Metamediausa.com) This analysis is provided in Table 3.2 below. Note that this examination only yielded three cognitive levels: knowledge, application and analysis. Also, note that in earlier units, the percentage of knowledge based questions was higher and the number of questions testing application and analysis increased in the later part of the course with the exception of Unit 8 which was a basic introduction to the global positioning system. This trend could be expected since the intensity of questions requiring mathematical computation increased in the later units of the course.

Table 3.2 FSG Course (SURV 2501) Spring 2009 – Fall 2011 Quiz Question – Cognitive Level Evaluation

Unit Test- Unit #	Description	K	C	A1	A2	S	E
1. (ch 1) & (ch2)	Surveying-Broad Intro. What? Units: Sig. Fig. & Field Notes	45.2%	--	48.4%	6.4%	--	--
2. (ch3)	Errors in Surveying	25.0%	--	5.0%	70.0%	--	--
3. (ch 4)	Leveling: Theory, Methods & Equipment.	70.0%	--	--	30.0%	--	--
4. (ch 5) & (ch 6)	Leveling: Field Proceedings & Computations. & Distance Measurement	5.0%	--	--	95.0%	--	--
5. (ch 7) & (ch 8)	Angles, Azimuths & Bearings. & Total Station Instrument Angle Measurements	7.5%	--	30.0%	62.5%	--	--
6. (ch 9) & (ch 10)	Traversing & Traverse Computations.	--	--	--	100%	--	--
7. (ch 11) & (ch 12)	Coordinate Geometry in Surveying Calculations & Area Calculations	--	--	2.4%	97.6%	--	--
8. (ch 13), (ch 14) & (ch 15)	GPS Introduction, GPS-Static & GPS Kinematic	60.0%	--	2.5%	37.5%	--	--
Average of Percentage Levels		26.6%	--	11.0%	62.4%	--	--

Bloom's Cognitive Levels (McBeath, 1992):
K – Knowledge – Remembering previously learned information
C - Comprehension – Grasping the meaning of information
A1 – Application – Applying knowledge to actual situations
A2 – Analysis – Breaking down objects or ideas into simpler parts and seeing how the parts relate and are organized
S – Synthesis – Rearranging component ideas into a new whole
E – Evaluation – Making judgments based on internal evidence or external criteria

3.1.3.2 Summative Assessment-Final Exam

The final exam was a summative exam (control test) and served as a comparison of the student performance between the control and experimental course offerings later in this study. Below, the questions within the final exam were examined for classification according to their cognitive levels. This analysis can be seen in the Table 3.3 given below. Note that this examination yielded four cognitive levels: knowledge, comprehension, application and analysis. Also, note that the percentages of the different quantitative levels in the final exam compare favorably to the averages of the percentages of the different quantitative levels given in the unit tests as seen above.

Table 3.3 FSG Course (SURV 2501) Spring 2009 – Fall 2011 Final Exam Question – Cognitive Level Evaluation

Exam	Description	K	C	A1	A2	S	E
Final Exam	Comprehensive (All Units)	28.0%	4.0%	4.0%	64.0%	--	--

Bloom's Cognitive Levels (McBeath, 1992):
K – Knowledge – Remembering previously learned information
C - Comprehension – Grasping the meaning of information
A1 – Application – Applying knowledge to actual situations
A2 – Analysis – Breaking down objects or ideas into simpler parts and seeing how the parts relate and are organized
S – Synthesis – Rearranging component ideas into a new whole
E – Evaluation – Making judgments based on internal evidence or external criteria

3.2 The Ideal Situation for the Online FSG Course

In this section, student characterization to inform student learning strategies-assessment and to help predict FSG course performance was evaluated assuming an ideal situation. Subsequently, an examination of the desired platform and pedagogy for the ideal course was performed. These activities were followed by a review of assessment planning for the ideal FSG course. Continuing, resources for the implementation of an ideal FSG course are discussed in terms of development/re-development & maintenance and an examination of the effect of an ideal FSG course on future s-g course requirements is examined. Finally, the course coverage required for surveying licensure requirements in the ideal FSG course is discussed.

3.2.1 Student Characterization

In this subsection, the useful elements of student characterization in determining student learning strategies-assessment and course performance prediction in the ideal FSG course were reviewed. It was anticipated that for pre-course and institutional data, collecting the correct data, collecting complete data and processing & analyzing the data to provide useable information were all paramount in an ideal FSG course. Thus, for this discussion, the student characterization data has been broken down into three categories which are given below.

3.2.1.1 Admissions Data

Admissions data was found to include cognitive and demographic data that can support correlations for prediction of course performance and groupings that support causal analysis. Useful cognitive data included such variables as SAT math & verbal scores, high school grade point average, high school course grades (English, math & Science), grades on previous college course work, and previous institution grade point averages. Useful demographic and related data included: city, state, high school, income per capita, age, gender, ethnicity, and military service.

In the ideal course situation, all FSG students would have values for all scaled variables and categorical variables from the above data group. Thus, an examination of correlation of these scaled variables would be performed via regression analysis to produce linear relationships (equations) between these variables and FSG course performance, performance on additional s-g courses and performance on the FS & PS exams. The categorical variables from the above data group would be used to perform causal-comparative analysis to identify trends of student performance in the FSG course, in additional s-g courses and on the FS & PS exams. These trends would be determined as a result of grouping according to the value of the selected individual categorical variable.

Resulting actions based on the results of the analysis described above would include the following elements:

- Closer analysis of FSG students projecting a grade of “D” or “F” in the FSG course including identification of individual pre-course academic strengths and weaknesses will be performed.
- Notification of the FSG student projecting a grade of “D” or “F” in a non-demeaning way to consider increasing study time above average levels will be provided.
- For FSG students projecting a grade of “D” or “F” in the FSG course, a determination will be made to see if there is a trend of poor performance in knowledge intensive subjects or skills intensive subjects. Based on this determination, additional resources to support improvement in knowledge acquisition or skill strengthening would be provided.
- For students projecting an “A” or “B” in the FSG course, a recommendation to try more advanced problems in the typical course material in order to maximize their benefit from the course would be issued.
- Based on the identification of the average of the FSG class projections where an average projection of a grade of “C” or less in the FSG course is indicated, course elements including assessments and supporting tools that allow for tweaking of content and coverage would be evaluated and applied.

3.2.1.2 Additional Program Entrance Survey

In order to complement the admission data discussed in the previous subsection, a program entrance survey would be required of the FSG student prior to he or she taking the first s-g course. This data would include background variables and affective responses. Background variables would include yes or no answers to the following questions:

- Do you have a parent or relative who is a surveyor or GIS analyst?
- Do you consider yourself to have a scientific orientation?
- Do you consider yourself to be a tinkerer?
- Do you enjoy solving mathematical problems?
- Do you have surveying or GIS work experience?
- Have you taken the NCEES' Fundamentals of Surveying exam?
- Do you enjoy using the computer?
- Do you enjoy working outdoors?
- Do you currently work at a full-time job?
- Are you using financial aid to pay for your s-g education and expenses?

The affective variables would be numeric responses to the following questions that are set up on a Likert scale where Strong = 5 and Weak = 1.

- How do you rate your mathematical ability?
- How would you rate your ability for completing academic activities?
- How would you rank your ability to solve problems?
- How would you rate your ability to follow instructions?
- How would you rate your ability to use computers?
- How would your rate your pre-course preparation for surveying-geomatics coursework?

Causal-comparative analysis as described in the previous subsection would be performed on this survey data and trends would be identified based on groupings according to the Likert responses. As an example, if students rate themselves with a high degree of resilience, then, these students as a group might also exhibit a strong tendency (trend) to be a successful surveyor and a strong tendency to do well in the FSG course. (That is, the group would trend toward making an “A” or “B” in the FSG course.)

3.2.1.3 Additional Testing Data

In order to further complement the student’s admission data, a program entrance test would be required of the FSG student prior to the first s-g course in the s-g program. This entrance exam would be a diagnostic test and no minimum score would be required. The test would focus on elementary algebra and trigonometric problems that would be anticipated in the FSG course. In a manner similar to the treatment of the admission data, regression analysis would be performed to determine if any linear relationship exists between the program entrance test and the FSG course performance, performance on additional s-g courses, and performance on the FS & PS exams.

3.2.2 The Ideal Online FSG Course Platform and Pedagogy

In an ideal situation, the cost of the online platform to be used for the FSG course would not be an obstacle. Thus, existing platforms such as Desire2Learn®, Moodle® and others should be investigated according to criteria that support an effective and efficient FSG course. Tools requiring evaluation would include the following:

- Email tools - Email tools should be user friendly and
- Discussion Tools
- Quiz Tools
- Chat/Conferencing Tools
- User-friendly course information structure
- Data Tools

All of these tools and structure would need the capacity to transfer large data files, image files, program files and document files within the course platform and have the ability to export these files outside the course platform.

An investigation of pedagogy approaches should be investigated to determine the ideal approach for the FSG course. This will be a time consuming task since the inclusion of the course covered technology and a plan to combat course compression should be included in the investigation. Methods containing project-based approaches, top-down problem approaches and portfolio approaches should be considered as some progress for these methods has been cited in the literature.

3.2.3 Assessment Planning for the Ideal Online FSG Course

As discussed in the literature, the ideal FSG course assessment must encompass defined course learning outcomes and program student learning outcomes. In order to accomplish this in the ideal FSG course, an assessment plan must be developed that is effective & efficient and provides for measurement and analysis of student learning. Thus, in the ideal situation, all available assessments and appropriate supporting applications should be reviewed in terms of their ability to accomplish the desired goals for the FSG course.

3.2.4 Resources for the Implementation of the Ideal Online FSG Course

Implementation of the ideal FSG course as a development/re-development process or a continuing process must be considered to insure the most effective and efficient FSG course. While these processes have some common aspects, it will be important to consider each process separately as given below.

3.2.4.1 Initial Course Development/Course Re-development

Resources for the Initial Development of the ideal FSG course includes the consideration of people and time resources while assuming that equipment and materials availability will be limitless. For personnel requirements, it was projected that properly qualified people including the course instructor and others will have expertise in developing content, graphics, quizzes, assignments, discussions, chat-video conferencing and media such as video-streaming. In consideration of time, all of the people mentioned above must have adequate time for development of course materials, communications amongst themselves and course assembly. Additionally, the instructor has to have time to take full ownership of the course prior to implementation.

Resources for the re-development of the ideal FSG course may include all of the resources required in the above paragraph if the course is a complete redo. Otherwise, the requirements of people and time may be dictated by the requirements of the course areas being updated or modified. For either a course development or re-development, all of the work must be performed with the goal of providing an effective and efficient course structure including an appropriate assessment plan.

3.2.4.2 Continuing Course Maintenance

Maintenance of the ideal FSG course would not be as time & manpower intensive as development/re-development and most of the required work may be done by the instructor. Maintenance requirements for the ideal FSG would include:

- Initial settings at the beginning of the course semester and checking of the course operation which might include checking link operation, content availability, quiz settings & updates, assignment settings, discussion settings, and checking media operation.

- Maintaining course operation throughout the semester.

As indicated, the course maintenance work can be performed mainly by the instructor. However, the experts mentioned in the above subsection will need to be available for consultation in a timely manner.

3.2.5 Future S-G Course Coverage Requirements

The application of algebra and trigonometry in the ideal FSG course to provide information such as distances, angles and coordinates must be covered to insure the success in courses taken after the FSG course such as Advanced Surveying, Geodesy and Construction Surveying. Thus, coverage for the ideal FSG course is a key requirement and can be insured by confirming the inclusion of these subjects according to the coverage description for these additional s-g courses. Also, coverage can be confirmed according to ABET guidelines.

3.2.6 FSG Course Coverage Requirements of Surveying Licensure

The ideal FSG course should provide appropriate coverage for addressing the future successful completion of the NCEES' FS and PS exams. The appropriate coverage can be established by documenting the exams' subject areas and being sure that the percentages of coverage in the ideal FSG course are similar to those required in the exams. The NCEES exams' coverage does change occasionally. Thus, the NCEES website should be reviewed annually to confirm the coverage.

3.3 Development of “Assessment for Learning” Methodology utilizing available Resources for the Online Experimental FSG Course Offerings

Many of the student characterization criteria as well as the course platform selection in the ideal FSG course situation are not possible in the short term of this study. Additionally, time and resources are generally limited. Therefore, the focus of this section will be to develop an improved methodology, “assessment for learning’, which was identified from the literature and contains many of the directly useable criteria from the ideal FSG course situation. Thus, in order to develop the “assessment for learning” methodology, existing resources must be utilized in an effective and efficient way. Thus, in order to develop a treatment based on “assessment for learning” for the experimental course offerings, the requirements of future s-g coursework beyond the FSG course and the requirements of the standardized testing for licensure were evaluated. Once these requirements were established, assessment and supporting methods can be identified that have been useful in other educational environments. From these methods, a selection based on online application constraints and student support requirements was performed. This selection was summarized in the developed “assessment for learning” assessment plan.

3.3.1 Requirements of Future Surveying-Geomatics Coursework

The advanced surveying course or sometimes called Surveying II typically follows immediately behind the FSG course and moves from the fundamental applications of distance and angle measurement to the “study of the principles of field astronomy and route surveying (horizontal and vertical curvature) and advanced surveying methods and calculations.” (MGSC Catalog 2013-2014. (n.d.). Retrieved from: http://www.mga.edu/academics/docs/catalogs/MGSC_2013-2014_Catalog.pdf) Additionally, the geospatial and geodetic coordinate systems are covered. Most of these applications utilize relationships, and mathematical equations (Trigonometry) covered in the FSG course.

Surveying students in associate degree programs and four year baccalaureate programs are typically required to take a course in geodesy. Geodesy as it is applied today relies heavily on the utilization of the global positioning system (GPS). Thus, today's surveyor as he or she learns how to establish surveying control networks for large tracts of land must understand how to work in both planar systems and systems which account for the earth's curvature. Again the student's background in distance & angle measurement and mathematical equations as learned in the FSG course are heavily relied upon. MGSC's catalog description for the geodesy course was given as follows: "The study of underlying GPS positional measurement theories as well as establishing an understanding of GPS system measurement methodologies and related measurement techniques. Also included is an introduction to the application of Geodesy to location control systems." (MGSC Catalog 2013-2014. (n.d.). Retrieved from: http://www.mga.edu/academics/docs/catalogs/MGSC_2013-2014_Catalog.pdf) Finally, looking at the requirements of surveying in construction, most s-g programs require that students take a course in construction surveying. Much like geodetic surveying, construction surveying is supported by many tools and methods. The correct selection of the tools and the correct utilization are required in order to improve accuracy and efficiency. Students must apply measurement techniques and reduction techniques learned in the FSG course. MGSC's catalog description for the construction surveying course: "The study of the applications of surveying instruments and methods to construction surveying, with an introduction to basic surveying field practices." (MGSC Catalog 2013-2014. (n.d.). Retrieved from: http://www.mga.edu/academics/docs/catalogs/MGSC_2013-2014_Catalog.pdf)

3.3.2 Requirements of Standardized Testing for Surveying Licensure

The knowledge requirements to support successful performance on the standardized exams for licensure as a Professional Surveyor can be seen in the NCEES summary documents for the Fundamentals of Surveying Exam (FS) and the Principles and Practice Surveying Exam (PS). For the FS exam which contains 110 multiple choice questions, the subjects, potential number of questions and related percentages are provided in Table 3.4. (NCEES Exam Summary, 2013) As can be seen in Table 3.4, based on the middle of the range as many as 61 questions (55.4%) of the 110 questions are based on material covered in the FSG Course.

Table 3.4 Knowledge Requirements for the NCEES – FS Exam covered in the FSG Course (SURV 2501)

Knowledge Subject		Range of Number of Questions	Middle of Range	Low of Range	High of Range
1.	Mathematics	13 - 20	17	13	17
2.	Basic Sciences	N/A	N/A	N/A	N/A
3.	Spatial Data Acquisition	6 - 9	7	6	9
4.	Survey Computations & Computer Applications	19 – 29	24	19	29
5.	Statistics & Adjustments	6 – 9	7	6	9
6.	Geodesy	5 – 8	6	5	8
7.	Boundary & Cadastral Survey Law	N/A	N/A	N/A	N/A
8.	Photogrammetry & Remote Sensing	N/A	N/A	N/A	N/A
9.	Survey Processes & Methods	N/A	N/A	N/A	N/A
10.	Geographic Information Systems	N/A	N/A	N/A	N/A
11.	Graphical Communication & Mapping	N/A	N/A	N/A	N/A
12.	Professional Communication	N/A	N/A	N/A	N/A
13.	Business Concepts	N/A	N/A	N/A	N/A
	Summary of Potential Number of Questions & Related Percentages		**61 or 55.4%**	**49 or 44.5%**	**75 or 68.1%**

For the PS exam which contains 100 multiple choice questions, the subjects include: Standards & Specifications, Legal Principles, Professional Survey Practices, Business/Professional Practices and Types of Surveys. Based on the stated subject percentages, it can be determined that as high as 55.4 percent of the questions was based on material covered in the FSG Course as indicated by mid-range values for the subject areas.

3.3.3 Selection of "Assessment for Learning" methods that Support Student Learning in the FSG Course

In order to select "assessment for learning" methods that support student learning in the FSG course, the following steps were taken. First, methods and techniques that are being practiced to improve student learning were examined. Second, from the available methods in the first step, the methods that can be supported online and are appropriate for the typical online FSG student were determined. Finally, these methods were placed in an assessment plan matrix which supports the FSG course structure.

3.3.3.1 "Assessment for Learning" Methods and Supporting Applications

Looking at the assessment standards and assessment terms utilized in the K-12 and the collegiate environment, (for example, authentic assessments are used extensively in both environments to support the student's ability to apply his newly found knowledge and skill) a listing of commonly held assessment and supporting applications was developed. The assessment terms identified below are commonly utilized by education researchers such as Chappius, Mertler and many others to define the assessment and supporting applications. These applications are shown in Table 3.5.

Table 3.5 Assessment and Supporting Applications

academic content standards	accountability	alternative assessment	analytic rubric	assessment
authentic assessments	assessment method	assessment system	benchmarks	checklist
constructivist	cooperative learning	criterion	criterion reference grading	curriculum
developmentally appropriate practice	educational equity	embedded assessment	equity evaluation	evaluation
formal assessments	formative evaluation	frameworks	hands-on-learning	individual assessment plans (IAPS)
informal assessments	inter-rater consistency	inquiry-based Learning	item analysis	key elements
learning styles	multiple intelligences	modeling	norm	norm-referenced assessment
performance standards	performance based assessment	reliability	rubric	objective assessment
pre-assessment or diagnostic assessment,	scaffolding	standard	standardized assessments	subjective assessments
summative evaluation	validity			

While many of these assessments and supporting applications may be easily installed in a traditional face-to face class, it is not necessarily true that they will be usable in an online class. (Chappius, 2009) (Mertler, 2003)

3.3.3.2 "Assessment for Learning" Applications and Related Supporting Applications that support Student Learning by the typical S-G Online Student

The assessment matrix for the assessment plan containing assessments and supporting applications for the FSG course as applied in the Spring 2012, Fall 2012, Spring 2013, Summer 2013 and Fall 2013 course offerings is given in Table 3.6 below. The reasoning for the assessment/application selection and a discussion of implementation is given below.

- **Pre-test:** The pre-test was selected to provide an opportunity for Diagnostic Assessment, Self- Evaluation, Feedback and Guidance. The pre-test was put in a regular test format with a grading score of 100 points and the pretest structure allowed for the student to see their score on the questions and total score. The pretest also provided feedback to the student about their potential knowledge and skill deficiencies in answering the question and guidance on how to improve their score by consulting their course textbook and related resources. Thus, the student had an opportunity for self-evaluation from his or her scores and the pre-test provided this information prior to the student accumulating any grade determining assessment in the course. The opening of the module quizzes (which counted toward the student grade) was set to be contingent upon the student successfully taking the learning module pretest. Thus, the pretest was selected because of its high degree of impact, support to the student and contribution to the "assessment for learning" methodology. It was suggested that the student complete the pretest (without reading the module material) on Mondays prior to the Chat on Tuesday.
- **Chat:** The chat tool was selected to provide more student interaction (between student & instructor and student & fellow student), to allow the student another mechanism for self-evaluation and to scaffold the learning requirements of the current module back to the knowledge and skills that the student(s) had practiced in their daily surveying work. The chat also allowed the students who were not practicing surveyors to get a layman's explanation of the field work/office work required (from fellow students) and to see how the knowledge and skill contained in the current module could be applied in real world applications. In the process of the chat, the students had the opportunity to perform self-evaluation of their knowledge versus the knowledge of their fellow student and how they

fared in understanding new concepts. The chat was facilitated by the instructor asking pre-determined questions and providing stimulating discussion. These questions were designed to work from the anticipated knowledge & skill level of the typical student while introducing new or expanded critical subjects from the specific learning module. Chats were held on Tuesday evenings during the semester at 7:00 pm. The students were instructed to do the pretest on Monday prior to the Chat on Tuesday. Also, it was suggested to the student that they should attend the chat without reading the current module material which allowed them to participate in the chat based on their own current knowledge level. Participation in the chat represented 5% of the student's final grade in the FSG course.

- **Discussions:** Discussions were provided in the earlier modules to facilitate a better knowledge of the fellow students' backgrounds beyond the mandatory introduction. Also, tools to improve reading skills were introduced that provided scaffolding back to their current habits and moved them forward in some cases to a more efficient reading technique and habit. It was hoped that these discussions benefited them in the future modules of the course as well. The discussions were required to be completed during the week assigned to the learning module. The discussions represented 5% of the student's final grade in the FSG course.
- **Module Quizzes:** The module quizzes as a group represented 30% of the student's course grade and provided an opportunity for a numeric assessment of the student learning in the learning module. The application of the module quizzes was such that the student could take the first module quiz only or take both module quizzes and the best score of the two was selected. The module quizzes also provided feedback to the student

about their potential knowledge and skill deficiencies in answering the questions and guidance on how to improve their score by consulting their course textbook and related resources. Thus, if the student performed poorly on the first module quiz, he/she had an opportunity to improve his/her recorded score for the second module quiz by utilizing the provided feedback and guidance and preparing accordingly. The module quizzes were constructed by utilizing preselected common questions and questioned developed from the learning module material. The module quizzes could only be taken after taking the module pre-test and the second module quiz was only available after taking the first module quiz. Module quizzes were released on Wednesdays and had to be completed by the following Sunday evening at midnight.

- **Performance Assessments:** Performance assessments were selected to allow the student an additional chance to improve on their performance level on problems that were studied in the Learning Modules leading up to the specific performance assessment module. In the FSG course, two performance assessments were created which were authentic in structure and content. A rubric was provided to the student for grading information and feedback that supported the student's preparation for the Final Exam, a summative assessment. The two performance assessments accounted for 30% of the student's final grade. The students were allowed one week to complete the performance assessments without any additional assignments.
- **Student Module Evaluations:** Student evaluations containing the same five questions were provided for each learning module. The coverage of questions in the evaluations included the students' perspectives on the components of the specific learning module and an indicator of their feeling with regards to their level of preparation going into the

module quizzes. The module evaluations were released on Wednesdays and were available to the student once the first module quiz was successfully taken. The evaluations had a deadline of Monday night (following the Sunday night deadline for the Module quizzes) at midnight.

- **Final Exam:** The final exam, a summative exam, for the course was evaluated as discussed above and it was decided that it would be comprehensive and could serve as a common or control assessment for both the control course offerings and experimental course offerings in this research.

Table 3.6 FSG Course (2501) Spring 2012 – Fall 2013 Typical Assessment Matrix

Module	Description	Mod. Start Date	Pre-test (0%)	Chat (5%)	Discussions (5%)	Module Quiz A* (30%)	Module Quiz B* (30%)	Performance Assessment (Rubric) (30%)	Student Module Evaluation (0%)	Final Exam (30%)
Start Here	Welcome, Syllabus & Schedule	1-10								
(ch 1)	Surveying-Broad Introduction. What?	1-16	X	X	X	X	X		X	
(ch2)	Units: Significant Figures &Field Notes	1-23	X	X	X	X	X		X	
(ch 4)	Leveling: Theory, Methods & Equipment	1-30	X	X	X	X	X		X	
(ch 5)	Leveling: Field Procedures & Computations	2-6	X	X	X	X	X		X	
(ch 6)	Distance Measurement	2-13	X	X	X	X	X		X	
(ch 7)	Angles, Azimuths & Bearings	2-20	X	X	X	X	X		X	
(ch 8)	Total Station Instrument Angle Measurements	2-27	X	X	X	X	X		X	
	Performance Assessment I Magnetic Bearing-Taping	3-5						X		
(ch 9)	Traversing	3-12	X	X	X	X	X		X	
(ch 10)	Traverse Computations	3-19	X	X	X	X	X		X	
(ch 11)	Coordinate Geometry in Surveying Calculations	3-26	X	X	X	X	X		X	
(ch 12)	Area (Calc.)	4-2	X	X	X	X	X		X	
	Performance Assessment II COGO-Traverse	4-9						X		
(ch 13)	GPS Introduction.	4-16	X	X	X	X	X		X	
(ch 3)	Errors in Surveying	4-23	X	X	X	X	X		X	
Final Exam	Comprehensive Exam	5-5								X
Applications of Assessment and supportive applications			**D.A., S.E. FB & G**	**S.E. & Scaff.**	**Scaff.**	**M.A., FB & G**	**M.A., FB & G**	**P.A.**	**(for affective analysis)**	**S.A. (Control Test)**

*The student highest grade from module quizzes A & B will be included in final grade calculation. Abbreviations: D.A. = Diagnostic Assessment, S.E. = Self Evaluation, FB = Feedback, G = Guidance, Scaff. = Scaffolding, M.A. = Module Assessment, P.A. = Performance Assessment and S.A. = Summative Assessment. (%) = Course Final Grade calculation percentages.

3.4 Pilot Application of "Assessment for Learning" methodology as contained in MGSC's Spring 2012 FSG Course Offering

A pilot application of the modified FSG course was offered in the Spring 2012 semester. This decision turned out to be very beneficial since the new course treatment included the above "assessment for learning" applications and the following course structural changes:

- **Course schedule coverage:** The course schedule coverage went from a basically a limited unit test schedule to a complete learning module based structure.
- **Student Learning Materials Organization:** The new learning module construction provided more definitive organization of student learning materials. There were a total of 15 new learning modules developed which included 13 student learning modules and 2 performance assessment modules. The control course construction only provided links to the unit information which was very limited as discussed earlier.
- **Depth of student learning materials provided:** In the new system, the learning module content included the following elements: Module Overview, Pretest Link, Chat Session Reminder (with directions to the Chat link), Textbook Chapter Commentary Notes (Platform; PowerPoint Show with audio based lecture), Homework Assignment Comprehensive Solutions Links, Supplemental Information Links (such as Georgia State Surveying laws, rules and policies), Module Quiz Links and a Module Evaluation link. In the old course structure, only a study guide with links to the supplemental notes was provided.

In order to accommodate many of the course structural changes, extensive work on course structural settings found in the online platform was required. Additional work was required to be sure that all learning module settings were the same where it was appropriate.

Thus, the pilot application in Spring 2012 was a huge success and made the transition from the GeorgiaView platform in Spring 2012 to the Desire to Learn® (D2L) platform in Fall 2012 much easier.

Finally, in reviewing the pilot application, the following findings were noted:

- The trial application of allowing the student the opportunity to take the module quiz three times was not successful in increasing the student' score on the quiz and students were not motivated to take the quiz three times. Thus, the learning module structure was quickly changed to two distinct module quizzes for each module.
- After a few learning modules were completed, it became apparent that students have to be reminded about completing the Student Module Evaluation and it was decided to remind the students during the Chat sessions.
- Finally, it was acknowledged that students need to be reminded that they can submit homework problems or text problems (via scan-email or fax) for review by the instructor.

CHAPTER 4

APPLICATION AND MEASUREMENT OF IMPACTS OF NEW ASSESSMENT METHODOLOGY

With the assessment methodology in place from Chapter 3, Chapter 4 is devoted to explaining how the treatment (or assessment plan) containing the "assessment for learning" methodology was applied in the online course structure and how the impacts of this treatment were measured for this case study. In order to determine the impacts of the treatment, the student academic performance was measured from the results of common questions found in the FSG course module quizzes and the control test or final exam (summative). Thus, it was necessary to explain how the common questions were selected and how the control test was evaluated. Finally, limitations of this case study with regards to assessment applications and measurements were presented.

4.1 Application of New Assessment Methods as contained in the Online Experimental FSG Course Offerings

The actual application of "assessment for learning" and the supporting applications can be seen by establishing the tools in Desire to Learn® (D2L), the online software platform. To facilitate the explanation, Table 4.1 has been provided. These utilized D2L tools were as follows:

- **Pre-test, Module Quizzes and Student Module Evaluations:** The tools for the Pre-test and Module Quizzes and Student Module Evaluations were included in the Question Library and Manage Quizzes Tools. The Question Library was used to set up quiz questions categorically and to assign the number of points per question. While the Manage Quiz Tools were used to set properties, restrictions (calendar offering dates/times), attempts, submission view (releasing quiz information to student) and to add/edit questions. The Pre-tests and Module Quizzes contain a range of 5 to 20 questions which were typically multiple choice and fill-in-the blank type questions. The Student Module Evaluations contain five questions which are multiple choice and short answer types.

- **Chat:** The chat tools provided in D2L were the Chat List which indicated all Chats that had been established and the New Chat tools that allowed the setup of a new chat. Chats as applied in the course included texting and limited sketching. A reminder for the chat session was placed in the module content and a Chat session of 60 minutes was provided for each instructive learning module.
- **Discussion:** The discussions were handled in D2L using the Forum & Topics List and related settings. New Forums and topics could be created as necessary in the course under the Forum & topics List. Settings that were utilized included display and view (threaded/unthreaded).
- **Performance Assessments:** Performance assessments were handled in a fashion similar to regular course content. The assessment and related rubric were posted utilizing the File Manager and Course Builder tools in D2L. Students were required to return the completed assessment in D2L email. There were two performance assessments applied in the course.
- **Control Test (Final Exam):** The control test was administered as a typical paper and pencil test on campus. This effort required the students to come to campus unless they were from out of state, in which case, the student was allowed to utilize a prequalified

proctor to administer the exam. The final exam was set up as a twenty-five question exam with fill-in-the-blank, short answer and multiple choice question types.

Table 4.1 FSG Course (2501) Spring 2012 – Fall 2013 D2L Tools-Assessment Matrix

Module #	Pre-test (0%)	Chat (5%)	Discussions (5%)	Module Quiz A* (30%)	Module Quiz B* (30%)	Perf. Assess (Rubric) (30%)	Student Mod. Eval. (0%)	Final Exam (30%)
Surveying Introduction	Question Library/Manage Quizzes	Chat List/Setup	Forums & Topic List/Setup	Question Library/Manage Quizzes	Question Library/Manage Quizzes		Question Library/Manage Quizzes	Quest Library/Manage Quizzes
Units, Significant Figures and Field Notes	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Leveling-Theory, Methods & Equipment	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Leveling-Field Procedures & Comps	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Distance Measurement	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Angles, Azimuths and Bearings	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Total Station Angle Measurements	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Performance Assessment I						Course Builder/File Manager		
Traversing	Question Library/Manage Quizzes	Chat List/Setup	Forums & Topic List/Setup	Question Library/Manage Quizzes	Question Library/Manage Quizzes		Question Library/Manage Quizzes	Question Library/Manage Quizzes
Traverse Computations	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Coordinate Geometry	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Area Calculations	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Performance Assessment II						Course Builder/File Manager		
GPS Introduction	Question Library/Manage Quizzes	Chat List/Setup	Forums & Topic List/Setup	Question Library/Manage Quizzes	Question Library/Manage Quizzes		Question Library/Manage Quizzes	Question Library/Manage Quizzes
Errors in Surveying	"	Chat List/Setup	Forums & Topic List/Setup	"	"		"	"
Final Exam								Paper & Pencil
Applications of Assessment and supportive applications	**D.A., S.E. FB & G**	**S.E. & Scaff.**	**Scaff.**	**M.A., FB & G**	**M.A., FB & G**	**P.A.**	**(for affective analysis)**	**S.A. (Control Test)**

*The student highest grade from module quizzes A & B will be included in final grade calculation. Abbreviations: D.A. = Diagnostic Assessment, S.E. = Self Evaluation, FB = Feedback, G = Guidance, **Scaff. = Scaffolding, M.A. = Module Assessment, P.A. = Performance Assessment and S.A. = Summative Assessment. (%) = Course Final Grade calculation percentages.**

4.2. Development of Student Academic Performance Measurement Instruments

Initially, it was thought that the control test (final exam) would be the only student academic performance metric available. However, after a careful examination of the Unit Quizzes in the control course offerings, it became apparent that common questions from appropriate subject areas were available. Thus, it was decided to utilize common questions (as an additional instrument) from the control course offerings in the experimental course offerings for comparison of student performance since they were consistent throughout all of the control course offerings. It was also obvious that all of the quiz questions for each subject/topic from the control course offerings were not necessary or were redundant. Thus, a method for common question selection was created. This method and the examination of the control test (final exam) were developed as given below.

4.2.1 Unit Quiz – Module Quiz Common Quiz Questions Selection Process

The selected approach for establishing the common questions included categorizing the questions and then selecting the questions that were included in the experimental course offerings. These two steps are explained below.

4.2.1.1 Unit Quiz – Module Quiz Common Question Categorization

As a first step, the Unit Quiz questions from the control course offerings had to be categorized according to subject areas using the course text and course content for guidance. From these categories, dominate subject areas within the module topic coverage were identified from which to select the common questions. Question development in the experimental course offerings for Pre-tests, and Module Quiz A & Module Quiz B in each instructive module was performed during the Spring 2012 FSG course pilot application. Thus, based on lessons learned from the Spring 2012 FSG course application, the Module Quiz A & B was chosen for inclusion of common questions. As an example, for Learning Modules 1 and 2 in the experimental course, (which combined covered the same basic material as Unit 1 in the control course offerings), the categories of Geodetic versus Plane, Specialized types of Surveying, Units/Metrics, Unit Conversions, and Significant Figures were determined to be appropriate categories for common question selection.

4.2.1.2 Unit Quiz – Module Quiz Common Question Selection

In order to make a selection of individual questions within the pre-determined categories, a method had to be established. Thus, since the data from the control offerings was already available, it was decided that the process for common questions selection should be based on the question occurrence frequency and the actual percentage of correct responses. The selection process included the following steps:

- Using data from the GeorgiaView database (The GeorgiaView course database allows standard output in the form of .csv files for all quizzes that are set up in the quiz question banks and are programmed in the course. These statistic output files allow determination of question occurrences and correct question responses.) available in the online course structure, individual question performance data were identified from each of the control course offerings and the data was aggregated for each individual question.
- Next, the following information was processed using Microsoft Excel®:
    - N – Number of question occurrences across all of the control course offerings
    - Actual # of correct responses for each question
    - Actual % of correct responses for each question

Sorting of the question data was performed according to the number of question occurrences in descending order.

- Utilizing the Unit Quiz ID taken from the GeorgiaView Question Bank, a classification and temporary ID was assigned to each question according to the experimental course question bank structure.
- Based on the new question classification and the actual percentage of correct responses, the questions were rated as follows:
    - High – The question with the highest percentage of correct responses
    - Median – The question with the median percentage of correct responses (When two median values were identified, both of the questions we used if needed, otherwise the lowest of the two values was used.)
    - Low – The question with the lowest percentage of correct responses
- Then, the rated questions were inserted into the Module Quiz "A" subareas according to the following criteria:
    - Where four questions were needed, Low, Median (1 &2) and High questions were inserted.
    - Where three questions were needed, Low, Median and High questions were inserted.
    - Where two questions were needed, Low, and Median questions were inserted.
- Finally, the common question selection method resulted in a group of questions that provided a broad range of topic coverage and allowed for analysis of the impact of experimental "assessment for learning" methods by comparing the student performance on these questions as provided in the control and experimental course offerings. Table

4.2 illustrates the application of the common question selection process which was based on the processed data. The results of all eight of the Unit Quizzes were disaggregated to establish the complete common question group which would fit into the thirteen instructional modules quizzes. All eight of the common question selection tables are provided in Appendix C. The actual percentages correct for each question represent the question performance for all control offerings of the course. Thus, these percentages are compared to the experimental course offerings later in this research. Note that the comparisons can be made at the question group level.

Table 4.2 FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Ex. Unit 1)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (4)		41	38	92.68		
	Sum (12)		40	31	77.50		
LM2-MQ2A UM 2	Sum (2)	2	40	39	97.50	Low	X
	Sum (quiz01_001)		40	39	97.50		
LM1-MQ1A Special 2	Sum (quiz01_002)	1	40	36	90.00	Low	X
LM1-MQ1A Special 1	Sum (quiz01_005)	1	40	40	100.00	High	X
LM2-MQ2A SF 3	Sum (13)	2	39	31	79.49	Med2	X
LM2-MQ2A SF 4	Sum (14)	2	39	26	66.67	Low	X
	Sum (19)		39	33	84.62		
	Sum (20)		39	37	94.87		
	Sum (quiz01_009)		39	24	61.54		
LM2-MQ2A UM 1	Sum (1)	2	38	38	100.00	High	X
	Sum (10)		38	27	71.05		
LM1-MQ1A Geo vs Plane 1	Sum (quiz01_003)	1	37	36	97.30	High	X
	Sum (15)		36	35	97.22		
LM2-MQ2A UC 4	Sum (3)	2	36	28	77.78	Med2	X
	Sum (5)		36	28	77.78		
	Sum (7)		36	26	72.22		
LM2-MQ2A SF 2	Sum (16)	2	35	29	82.86	Med1	X
	Sum (quiz01_006)		35	31	88.57		
	Sum (quiz01_007)		35	28	80.00		
LM2-MQ2A UC 4	Sum (6)	2	34	19	55.88	Low	X
LM2-MQ2A UC 6	Sum (8)	2	34	34	100.00	High	X
	Sum (11)		33	25	75.76		
	Sum (quiz01_011)		33	33	100.00		
LM2-MQ2A SF 1	Sum (17)	2	32	29	90.63	High	X
	Sum (18)		32	29	90.63		
	Sum (quiz01_010)		32	30	93.75		
LM2-MQ2A UC 2	Sum (9)	2	31	26	83.87	Med1	X
	Sum (quiz01_008)		31	28	90.32		
LM1-MQ1A Geo vs Plane 2	Sum (quiz01_004)	1	30	28	93.33	Low	X

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

4.2.2 Control Test (Final Exam) Development

The Final Exams (control tests) for the control course offerings were examined for consistency and coverage according to the FSG course learning objectives and the ABET testing criteria. Table 4.3 shows the distribution and coverage areas of the final exam questions according to the Fall 2009 - Fall 2011 exams. Note that the problem coverage was broken down as follows: elements in traverse computations (6 problems or 24%), bearing/declination problems (5 problems or 20%), errors & statistics (3 problems or 12%), distance measurement (3 problems or 12%), GIS/coordinate conversions (3 problems or 12%), leveling (2 problems or 8%) and definitions, note-taking and area (1 problem or 4% each). Comparing the question coverage breakdown with the course learning objectives indicates that all critical areas are covered in the final exam.

Table 4.3 FSG Course (2501) Fall 2009 – Fall 2011 Final Exam (Summative Exam) Coverage

Question #	Chapter	Subject Area
1.	3	Common Statistical Terms & Methods
2a.	6	Tape Problems
2b.	6	Tape Problems
3.	7	Meridians defining the Direction of a Line
4.	7	Magnetic Declination Problem
5.	13	Problems GPS Coordinate System Conversions-Coordinates
6.	1	Geodetic vs. Plane
7a.	7	Magnetic Declination Problem
7b.	7	Magnetic Declination Problem
8.	4	Leveling Definitions
9.	8	Mathematical Operations and Note Taking Procedures for Total Station
10.	10	Elements used in Traverse Computations
11.	6	Distance Measurement Methods
12.	7	Bearing System Problems
13.	3	Problems Applied to Errors-Product
14a.	10	Elements used in Traverse Computations
14b.	10	Elements used in Traverse Computations
14c.	10	Elements used in Traverse Computations
14d.	10	Elements used in Traverse Computations
14e.	12	Area by Coordinates
15.	5	Leveling Misclosure Adjustments
16.	13	GIS Data & Information
17.	13	GIS Data & Information
18.	10	Elements used in Traverse Computations
19.	3	Common Statistical Terms & Methods

With a favorable comparison of cognitive levels of the final exam with the Unit-Module quizzes and the alliance of the subject breakdown, it was decided to use the final exam as the control assessment (summative) in conjunction with the common questions as discussed above. The only change to the final exam for the experimental course offerings was the substitution of a different question for problems 16 and 17. The new problems fell in the same GIS Data & Information category and were at the same knowledge-cognitive level as the control course offerings. The actual percentage correct on the final exam was compared between the control course offerings and the experimental course offerings for all questions except problems 16 and 17.

4.3 Limits of Assessment Applications and Measurements

Since running parallel courses in this study was not an option due to the smaller numbers of FSG students, metrics to measure student academic performance were limited to those metrics available in the previous control offerings. Thus, the application and metrics utilized in the experimental course had to be repeated in the same manner to avoid bias. This constraint was possible since the quiz offering structure within the course platform was the same for the control and experimental courses offerings.

CHAPTER 5

STUDENT DATA DESCRIPTION

5.1 Data Collection: Data, Sources and Permissions

With the methods of measurement established in Chapter 4, the sources of the student data were identified. This student data included student characterization data and student academic performance data. Thus, for the student characterization data, the Middle Georgia College-Banner Database (Pre-merger) and the Middle Georgia State College Banner Database (Post-merger) were utilized. (Both of these databases were required because of the merger between Middle Georgia College and Macon State College. This merger was effective with the Fall 2013 semester which was the final experimental FSG course offering for this study. Figure 5.1 below illustrates the changes.) The Banner Databases are Oracle® databases which contain linked tables for data entry, query, analysis and extraction. Banner Databases are used by most of the University System of Georgia institutions and can be customized for each institution's needs.

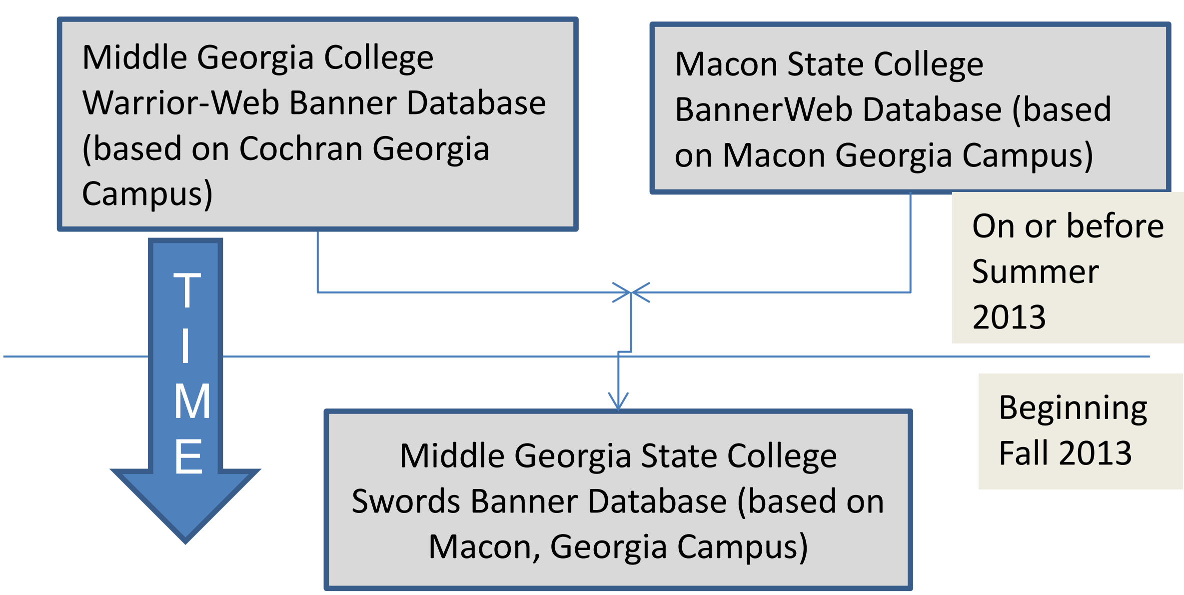


Figure 5.1 Banner Databases

For the student course academic performance data, the databases contained in the teaching platform programs for the FSG courses were used for the common question performance analysis while for the final exam (control test); the final exam documents were used. The acquisition process and permissions to use the student data are discussed in the following paragraphs.

5.1.1 MGC and MGSC Banner Databases

The process of acquiring the required student characterization began by performing a thorough examination of the MGC student forms and the entry fields in the Banner program required for application to the college. From this examination, a listing of desired data was developed including: admissions data, Banner matriculation data, student curriculum information data, student standardized test score data, degrees awarded data, total hours transferred data, specific course transfer data and specific course-MGC credit data. All of the data sets required a unique identifier for the student. The breakdown of the Banner data is given below in Table 5.1.

Table 5.1 Banner Database Student Data Table Breakdown

Admissions	Banner Matriculation	Student Curriculum	Standard Tests	Degree	Hours Transfer	Course Transfer	Course Credit
Sex	First and last term attended	Program admit term	Learning Support scores	Student degrees	Attempted hours	Credit & grade data for math & physics courses at transfer institutions	Credit & grade data for math & physics courses at MGC-MGSC
Ethnicity	Matriculation term	Admit type	CPC info.	Date of award	Passed hours		
Race		Major/ Dept.	SAT-ACT & Compass scores		Earned hours		
Date of birth	Residence				Grade point average hours		
Place of birth	Student type & class				Quality points		
Mailing address Permanent address					Grade point average for institution and transfer credits		
Previous college							
Residence-city/state							
Colleges &dates attended							
Credits earned							
Military service							
Standardized test(s)							

CPC- Deficiencies in College Preparatory Curriculum, SAT- Scholastic Aptitude Test covering Math, Verbal and Writing, ACT-American College testing Test covering English, Mathematics, Social Studies, and Natural Sciences, Compass: Advising test for students in English, Reading and Math (for minimum competencies)

The initial request for the above data was submitted to the Registrar & Director of Admissions of MGC, Jennifer Brannon, and was coordinated with Robin Porter, MGC Director of information Technology and Michelle Swafford, MGC Director of Institutional Research. Approval of the request and use of the data was granted on June 7, 2011 with the condition that the student mailing address & permanent address would not be released but the use of the student zip code or city/state would be allowed. Subsequent to this approval, an IRB (Institutional Review Board for Human Subjects) Research Protocol (Protocol H12209) approval was obtained from the Georgia Institute of Technology on July 27, 2012. The required Georgia Tech CITI Human Rights Training Certification was obtained on June 25, 2012. In conjunction with the merger of MGC and Macon State College in January 2013, a Research Project Approval (#201209B) was also obtained from the Macon State College IRB on September 26, 2012.

The actual initial data mining and transfer was facilitated by Mr. Richard Burnam of the MGSC IT Department. Based on the initial request, Mr. Burnam developed the data query and provided the resultant output data in a series of files which were ultimately transferred in a .csv (comma separated ASCII) format. The data processing and statistics development of this Banner data will be described in chapter 6.

5.1.2 Data from Online Course Database Structure: GeorgiaView, D2L-MGC and D2L-MGSC

Student academic performance data in the FSG course was taken from the database structure provided in the online course platforms for the control and experimental course offerings. In the control course offerings during the time period of Spring 2009 through Fall 2011, the online course platform was the GeorgiaView platform which was designed specifically for the University System of Georgia. In Spring of 2012, MGC went to the original University System of Georgia issue of the Desire to Learn (D2L) platform and in Fall of 2013, the combined institution, Middle Georgia State College, went to the current version of D2L platform. All of the above platforms have similar course tools for content, quiz development & management, communications, grading and submissions.

The data obtained from the course database structure included the students' performance on the unit-module quizzes and was obtained by exporting summaries which were available to the instructor in the course's Manage Quiz tools. The students' performances on the quizzes and the quiz questions (including the common questions) were obtained from the summaries which were downloaded in a .csv format. The students' performances were given on an individual and a class basis. Permissions for use of the student data from the course database structure are covered in the permissions cited in the previous section.

5.1.3 Data from the FSG Final Exam (Control Test)

Students' performance data for the final exam (control test), was taken directly from the paper test documents. Thus, results could be formulated on a question and exam level. Permission for use of the student data from the final exams (control tests) is covered in the permissions cited in the section 5.1.1 of this research.

.

CHAPTER 6

STUDENT CHARACTERIZATION

6.1 Student Characterization Overview

The student data that was discussed in Chapter 5 was utilized for characterization of the online surveying-geomatics (s-g) student population at Middle Georgia State College. For categorization purposes, the s-g students were divided into three groups to coincide with the required divisions of the project. The initial and largest group included those students who took the FSG course during the beginning years of online instruction at MGSC. These students involved in this initial period (Spring 2003 to Summer 2009) are referred to as the Introductory Group. The second group covered the period when the control assessment plan ("Assessment of Learning") was applied and will be referred to as the Control Group. (Note, for purposes of this research and due to data restrictions, the control group data was not collected at the same time as the experimental group data.) The last group covered the period when the experimental assessment plan ("Assessment for Learning") was applied and will be called the Experimental Group (pseudo-experimental application).

6.1.1 Variable Selection for Student Characterization

After removing duplicate data lines, the variables that were identified for student characterization include: Student Age, High School Grade Point Average, Student Sex, SURV 1500/MATH 1112 Grades, SURV 2501 Grades, Institution Cumulative Credit Hours, and Institution Grade Point Average. These variables were selected by examining the degree of completeness of the data for the particular variable and for their perceived ability to define the

FSG student. Student Age suggests a level of maturity in attempting coursework such as s-g courses. The High School Grade Point Average is a measure of the academic performance of the student at a previous point in the student's career and it was anticipated that this performance may be projected to continue into the future s-g courses. Student sex defines the student physically. The Surveying Course grade variables, the Institution Cumulative Credit Hours and the Institution Grade Point Average are measures of the academic performance of the student and may also be used to project the student's future performance. These variables are listed by code name in Table 6.1 and defined below:

- Student Age: The Student Age is defined as the student's age in years at the beginning of the first semester. (Scale-Floating Point Variable)
- High School Grade Point Average: The Student's High School Grade Point Average (HSGPA) is the student's grade average at the completion of High School based on a 0 to 4.0 scale. (Scale-Floating Point Variable)
- Student Sex: The student's sex is male or female. (Categorical Variable)
- SURV 1500/MATH 1112 Grades: The SURV 1500/MATH 1112 Grade is the Student's numeric grade in SURV 1500, Elementary Surveying Calculations or MATH 1112, College Trigonometry. If the student took both courses, the highest grade of the two grades was listed. These two courses are very similar in their ability to provide to the s-g student the necessary background in Trigonometry and to prepare the s-g student to take the FSG course. This grade can have a value of A (90-100), B (80-89), C (70-79), D (60-69) or F (0-59). (Categorical Variable)
- SURV 2501 Grades: The SURV 2501 Grade is the student's numeric grade in the FSG course - SURV 2501, Plane Surveying. This FSG course introduces the study of the theory

and practice of plane surveying using the traditional methods of surveying, including pacing, taping, and the use of the compass, transit (theodolite-total station), and level. Thus, the course represents a bridge for students from the strictly mathematical concepts of algebra and trigonometry to more complex concepts and applications which are utilized throughout the surveying-geomatics curriculum. The SURV 2501 Grade can have a value of A (90-100), B (80-89), C (70-79), D (60-69) or F (0-59). (Categorical Variable)

- Institution Cumulative Credit Hours: The student's Institution Cumulative Credit Hours (ICCH) at Middle Georgia State College represents the accumulated credit hours for courses taken at Middle Georgia State College. The ICCH includes credit hours for all the courses taken at MGSC by the date of the recent query, January 14, 2014. (Scale-Floating Point Variable)
- Institution Grade Point Average: The Student's Institutional Grade Point Average is the Cumulative Grade Point Average at Middle Georgia State College. This average is determined by dividing the Institution Quality Points by the Total Credit Hours taken (for credit). This average can be adjusted for courses that are repeated where the grade in the new grade is higher than the previous grade. (Scale-Floating Point Variable)

Table 6.1 S-G Student Characterization Variables

Variable Code Name	**Variable Name**	**Variable Type**
Age	Student Age	Scale-Floating Point Variable
HSGPA	High School Grade Point Average	Scale-Floating Point Variable
SEX	Student Sex	Categorical Variable
@15001112GRADE	SURV 1500/MATH 1112 Grades	Categorical Variable
@2501GRADE	SURV 2501 Grades	Categorical Variable
ICCH	Institution Cumulative Credit Hours	Scale-Floating Point Variable
IGPA	Institution Grade Point Average	Scale-Floating Point Variable

6.2 Student Characterization by Period

In the following sections, the variables defining the student characterization were reviewed in terms of Descriptive statistics. The data groups were examined and compared in order to show the similarities of the groups and to give limited validity for the experimental versus control group comparisons provided in the next chapter of this research.

6.2.1 Student Characterization: The Introductory Group

6.2.1.1 Student Age

As can be seen in the Table 6.2, the average student age for the Introductory Group is 32 years. The total age range is 18 – 58.8 years while the range between the 10 and 90 percentile averages is 21.9 – 46.0 years. Getting younger students to take s-g courses is important for the future of the surveying profession where the mean age of the surveying professional is in the mid to late 50s. Figure 6.1 shows that the distribution of students was shifted to the youthful side of the mean.

Table 6-2 Introductory Group: Student-Age Statistics

N	Valid	578
	Missing	0
Mean		31.996
Median		29.475
Mode		21.0[a]
Std. Deviation		9.3210
Range		40.7
Minimum		18.0
Maximum		58.8
Percentiles	10	21.898
	90	46.036

a. Multiple modes exist. The smallest value is shown

Figure 6.1 Introductory Group: Student Age Histogram

6.2.1.2 High School Grade Point Average

As can be seen in Table 6.3, the average High School Grade Point Average (HSGPA) for the Introductory Group is 2.35 was lower than might be expected when compared to students in face-to-face programs where the entrance requirements would be higher. As an example, the HSGPA requirement for entering freshman at Southern Polytechnic State University (The only other University System of Georgia institution offering s-g courses) is 2.5. (Anon., "Freshman Admissions", http://www.spsu.edu/undergraduate/admission/freshman.htm, accessed March 24, 2014) However, given the age statistics, it is apparent that many of the students went to High School 20+ years ago before the more recent upward grade creep. (Anon., Issues in College Readiness: Are High School Grades Inflated?, ACT, 2005) The histogram in Figure 6.2 reveals the distribution of the student GPAs. Additionally, many of the GPA records are missing from the overall group which is expected since many of the students may not have been required to provide their HSGPA at admission to MGSC. The mean reflects only the students that provided their HSGPA. Thus, approximately 22% of the population is represented. However, the distribution appears to be almost normally distributed with the exception of the spikes at the 2.0 to 2.25 range and the 3.0 to 3.25 range.

Table 6.3 Introductory Group: HSGPA Statistics

N	Valid	127
	Missing	451
Mean		2.354
Median		2.350
Std. Deviation		.5491
Range		2.9
Minimum		1.0
Maximum		3.9

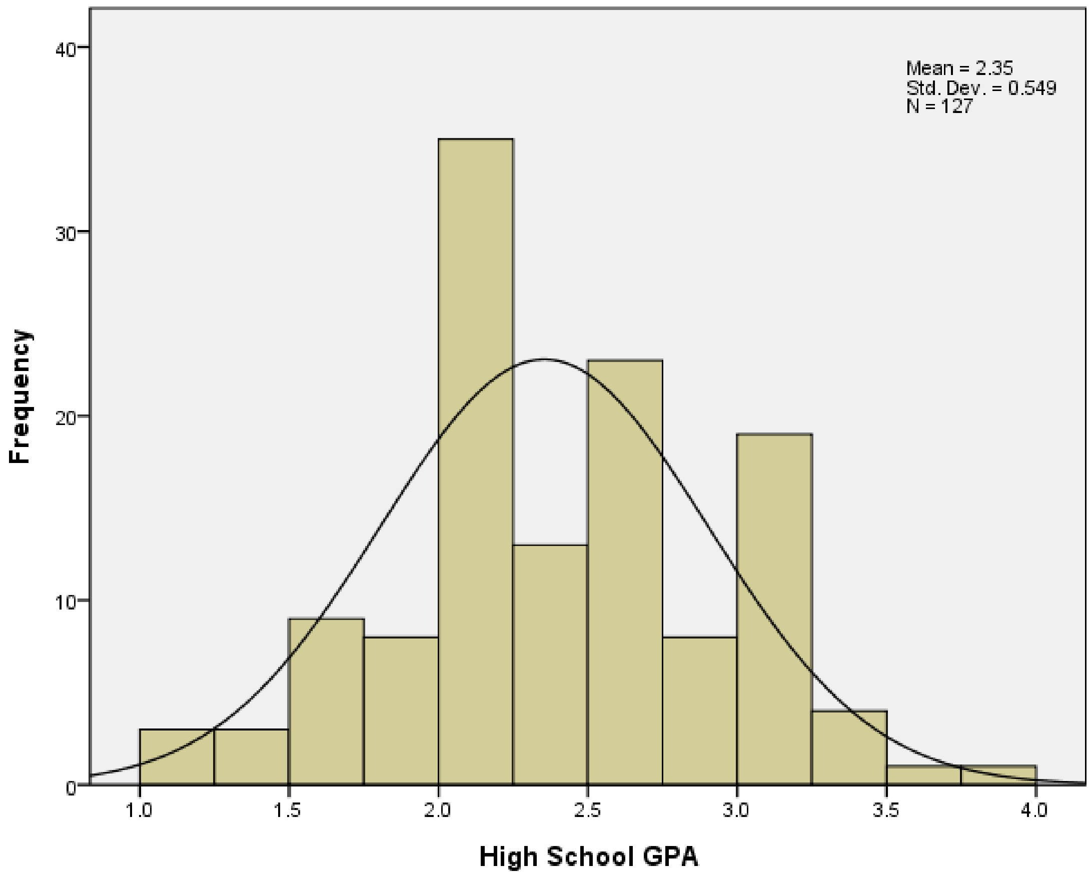


Figure 6.2 Introductory Group: HSGPA Histogram

6.2.1.3 Student Gender

Table 6.4 indicates that the surveying profession is dominated by males. In this case, 95.3% males and 4.7% females are represented.

Table 6.4 Introductory Group: Student Sex Breakdown

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	27	4.7	4.7	4.7
	Male	551	95.3	95.3	100.0
	Total	578	100.0	100.0	

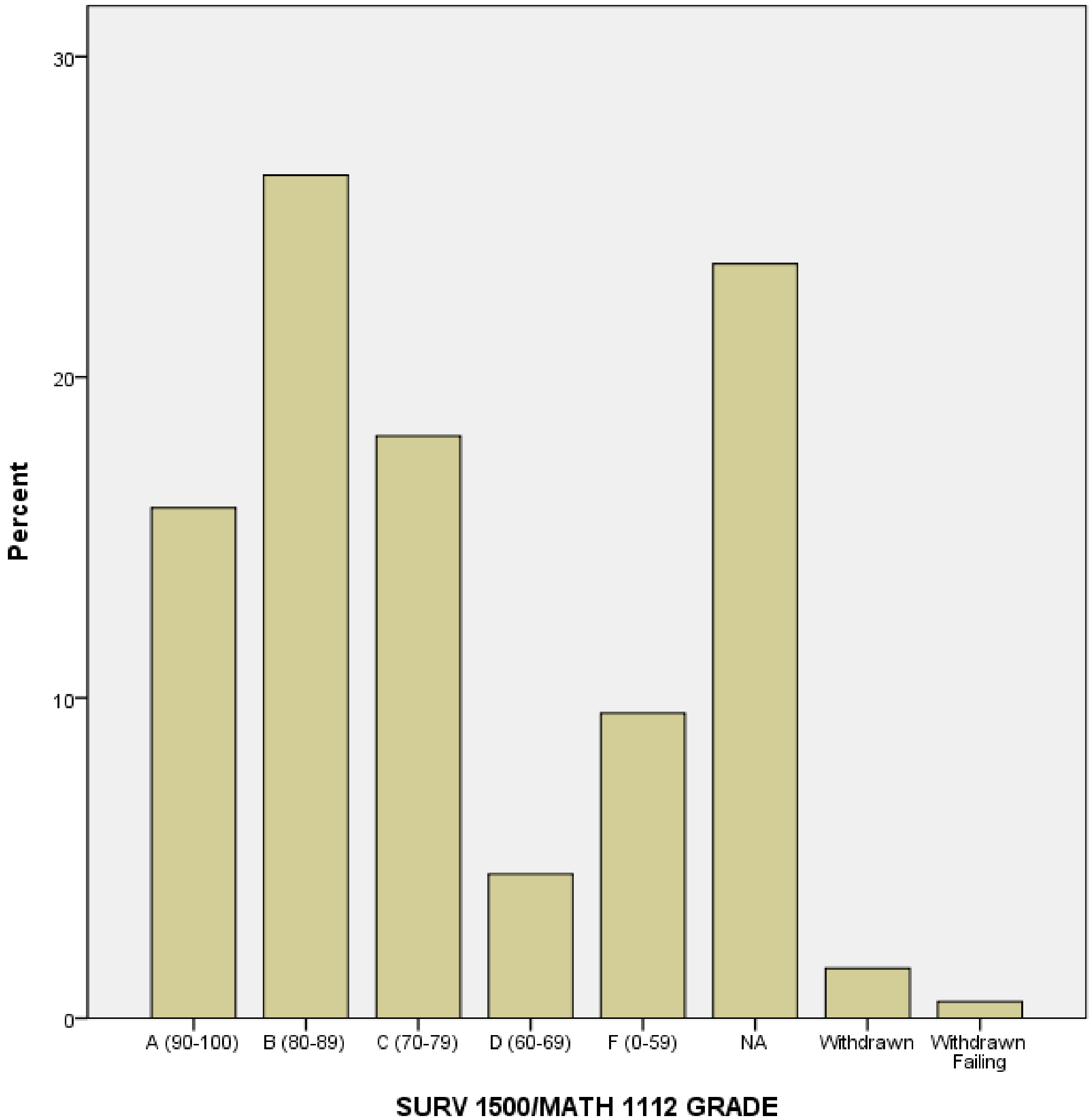
6.2.1.4 SURV 1500/MATH 1112 Grades

In the Introductory Group, the SURV 1500/MATH 1112 courses were provided to the s-g student to give the Math background necessary for the FSG course. Table 6.5 shows that the cumulative percentage for grades “C” and higher in these courses is 60.4%. This cumulative percentage for grades “C” and higher is an important factor since a grade of “D” or “F” in any of the MGSC s-g courses will cause the course to have to be repeated. The distribution seen in Figure 6.3 emphasizes a shift to the higher end of the grade range with the most prevalent grade being a “B” at 26.3%.

Table 6.5 Introductory Group: SURV 1500/MATH 1112 Grades

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A (90-100)	92	15.9	15.9	15.9
	B (80-89)	152	26.3	26.3	42.2
	C (70-79)	105	18.2	18.2	60.4
	D (60-69)	26	4.5	4.5	64.9
	F (0-59)	55	9.5	9.5	74.4
	NA	136	23.5	23.5	97.9
	Withdrawn	9	1.6	1.6	99.5
	Withdrawn Failing	3	.5	.5	100.0
	Total	578	100.0	100.0	

NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.



NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.

Figure 6.3 Introductory Group: SURV 1500/MATH 1112 Grade Percentages

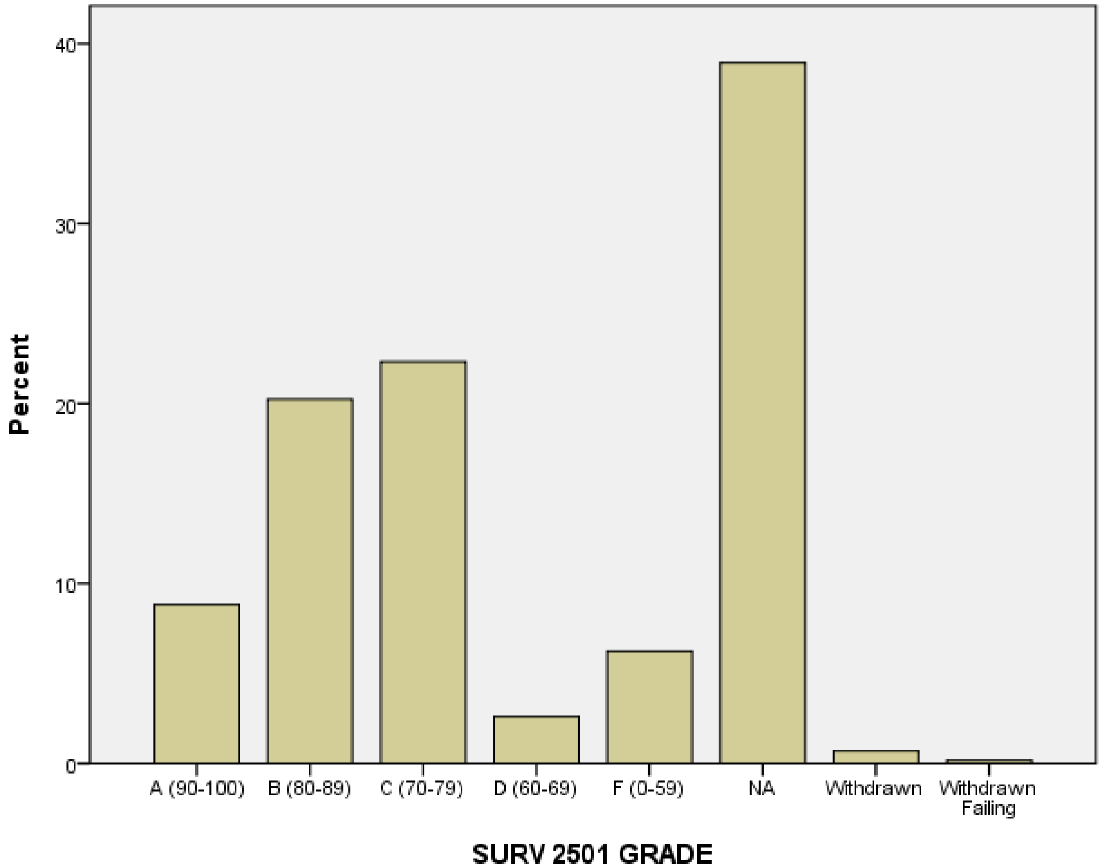
6.2.1.5 SURV 2501 Grades

Since SURV 2501 is the FSG course, the cumulative percentage for grades of “C” and higher (for students attempting the course) is extremely important since a grade of “D” or “F” in any of the MGSC s-g courses will cause the course to have to be repeated. In the Introductory Group, Table 6.6 shows that this cumulative percentage is 51.4% which is 9 points lower than the SURV1500/MATH 1112 percentage. The grade distribution shown in Figure 6.4 indicates that the “C” grade is the most common at 22.3%.

Table 6.6 Introductory Group: SURV 2501 Grade Percentages

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A (90-100)	51	8.8	8.8	8.8
	B (80-89)	117	20.2	20.2	29.1
	C (70-79)	129	22.3	22.3	51.4
	D (60-69)	15	2.6	2.6	54.0
	F (0-59)	36	6.2	6.2	60.2
	NA	225	38.9	38.9	99.1
	Withdrawn	4	.7	.7	99.8
	Withdrawn Failing	1	.2	.2	100.0
	Total	578	100.0	100.0	

NA: Denotes that the student was not required to take this course due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.



NA: Denotes that the student was not required to take this course due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.

Figure 6.4 Introductory Group: SURV 2501 Grade Percentages

6.2.1.6 Institution Cumulative Credit Hours

The Institution Cumulative Credit Hours (ICCH) represents the sum of the student's course credit hours obtained at MGSC. As shown in Table 6.7, the average ICCH for the Introductory Group is 12.27 hours which represents the average accumulated hours at the data query date of January 14, 2014. This average represents an equivalent of approximately 4 @ 3 hour academic courses. Zero values for the ICCH indicates that the s-g student was probably not successful in either SURV 1500 or Math 1112 and basically dropped from the s-g program. The percentage evaluation in Figure 6.5 indicates that 13.8% or 80 students had an ICCH of zero.

Table 6.7 Introductory Group: Institution Cumulative Credit Hours

N	Valid	578
	Missing	0
Mean		12.27
Median		9.00
Mode		6
Std. Deviation		11.085
Range		116
Minimum		0
Maximum		116
Percentiles	25	3.00
	50	9.00
	75	21.00

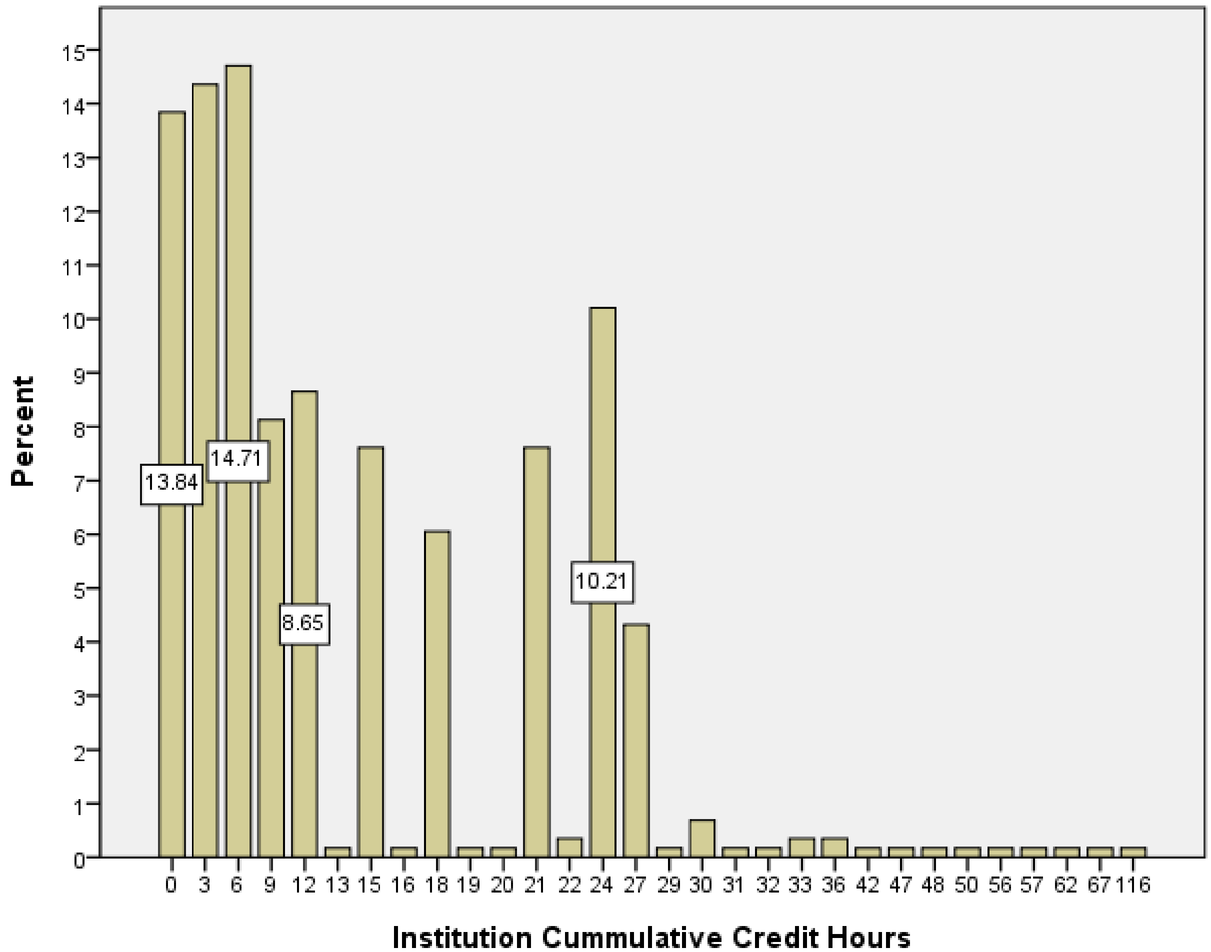


Figure 6.5 Introductory Group: Institution Cumulative Credit Hours

6.2.1.7 Institution Grade Point Average

As shown in Table 6.8, the Institution Grade Point Average (IGPA) for reporting students is 2.37 out of 4.0 which is very similar to the HSGPA at 2.35 out of 4.0. The frequency of the GPA distribution is shown in Figure 6.6 where a large degree of scatter is indicated with most of the grades being higher than the 2.0 category. Zero values for the IGPA indicates that the s-g student was probably not successful in either SURV 1500 or Math 1112 and basically dropped from the s-g program. The percentage evaluation in Figure 6.5 indicates that 13.8% or 80 students had an IGPA of zero.

Table 6.8 Introductory Group: IGPA Statistics

N	Valid	578
	Missing	0
Mean		2.371
Median		2.667
Mode		.0
Std. Deviation		1.2634
Range		4.0
Minimum		.0
Maximum		4.0
Percentiles	25	1.500
	50	2.667
	75	3.333

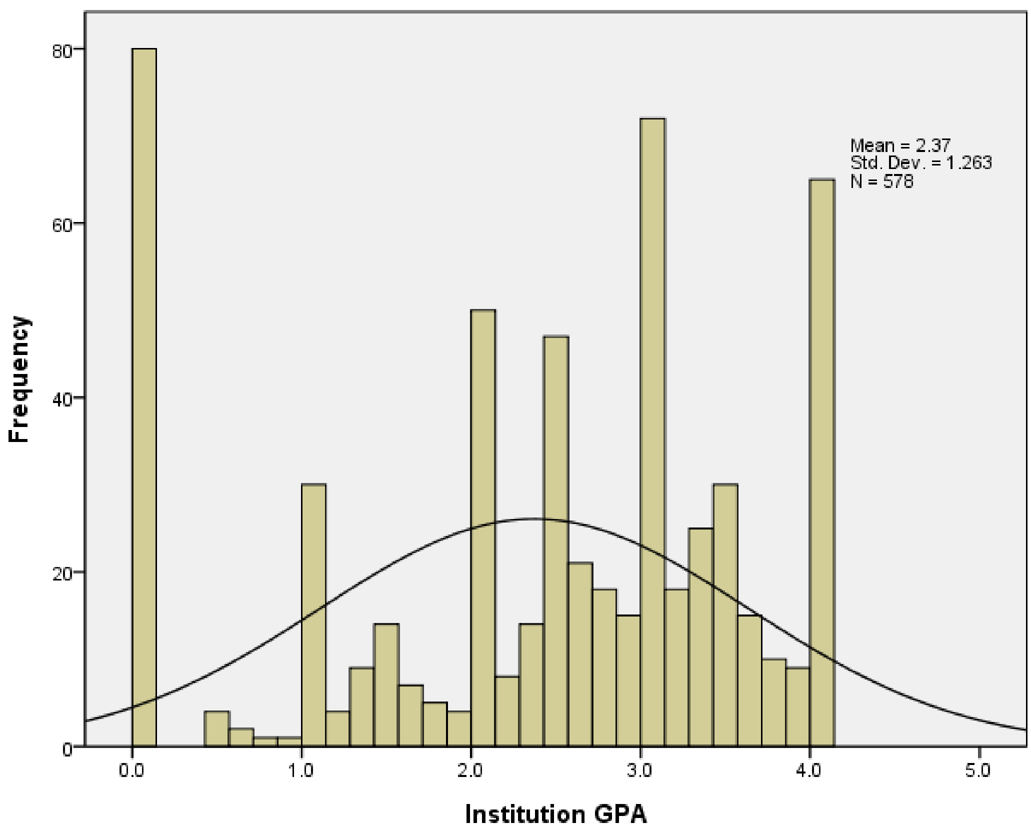


Figure 6.6 Introductory Group: IGPA Distribution

6.2.2 Student Characterization: The Control Group

6.2.2.1 Student Age

As can be seen in the Table 6.9, the average student age for the Control Group is 33.8 years. The total age range is 18.1 – 66.9 years while the range between the 10 and 90 percentile averages is 20.7 – 50.0 years. Getting younger students to take s-g courses is important for the future of the surveying profession where the mean age of the surveying professional is in the mid to late 50s. Figure 6.7 shows that the distribution of students is shifted to the youthful side of the mean.

Table 6.9 Control Group: Student Age Statistics

N	Valid	51
	Missing	0
Mean		33.796
Median		31.500
Mode		18.1[a]
Std. Deviation		11.0007
Range		48.8
Minimum		18.1
Maximum		66.9
Percentiles	10	20.700
	90	49.980
a. Multiple modes exist. The smallest value is shown		

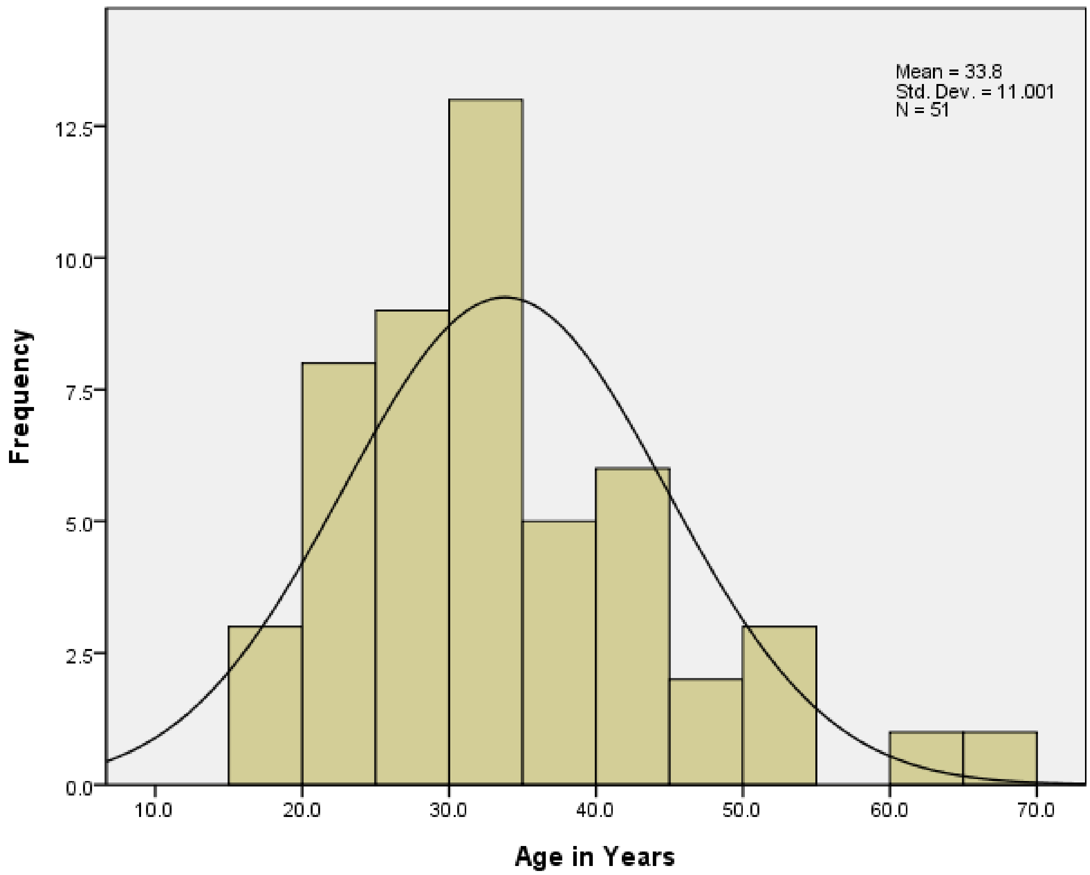


Figure 6.7 Control Group: Student Age Histogram

6.2.2.2 High School Grade Point Average

As can be seen in Table 6.10, the average High School Grade Point Average (HSGPA) for the Control Group is 2.4 which is lower than might be expected when compared to students in face-to-face programs where the entrance requirements would be higher. As an example, the HSGPA requirement for entering freshman at Southern Polytechnic State University (The only other University System of Georgia institution offering s-g courses) is 2.5. (Anon., “Freshman Admissions”, http://www.spsu.edu/undergraduate/admission/freshman.htm, accessed March 24, 2014) The histogram in Figure 6.8 reveals the distribution of the student GPAs. Additionally, many of the GPA records are missing from the overall group which is expected since many of the students may not have been required to provide their HSGPA at admission to MGSC. The mean reflects only the students that provided their HSGPA. Thus, approximately 25.4% of the population is represented. However, the distribution In Figure 6.8 appears to be almost normally distributed with the exception of a spike at the 2.0 to 2.5 range and a low at the 2.5 to 3.0 range.

Table 6.10 Control Group: HSGPA Statistics

N	Valid	13
	Missing	38
Mean		2.404
Median		2.130
Std. Deviation		.6456
Range		2.3
Minimum		1.8
Maximum		4.0

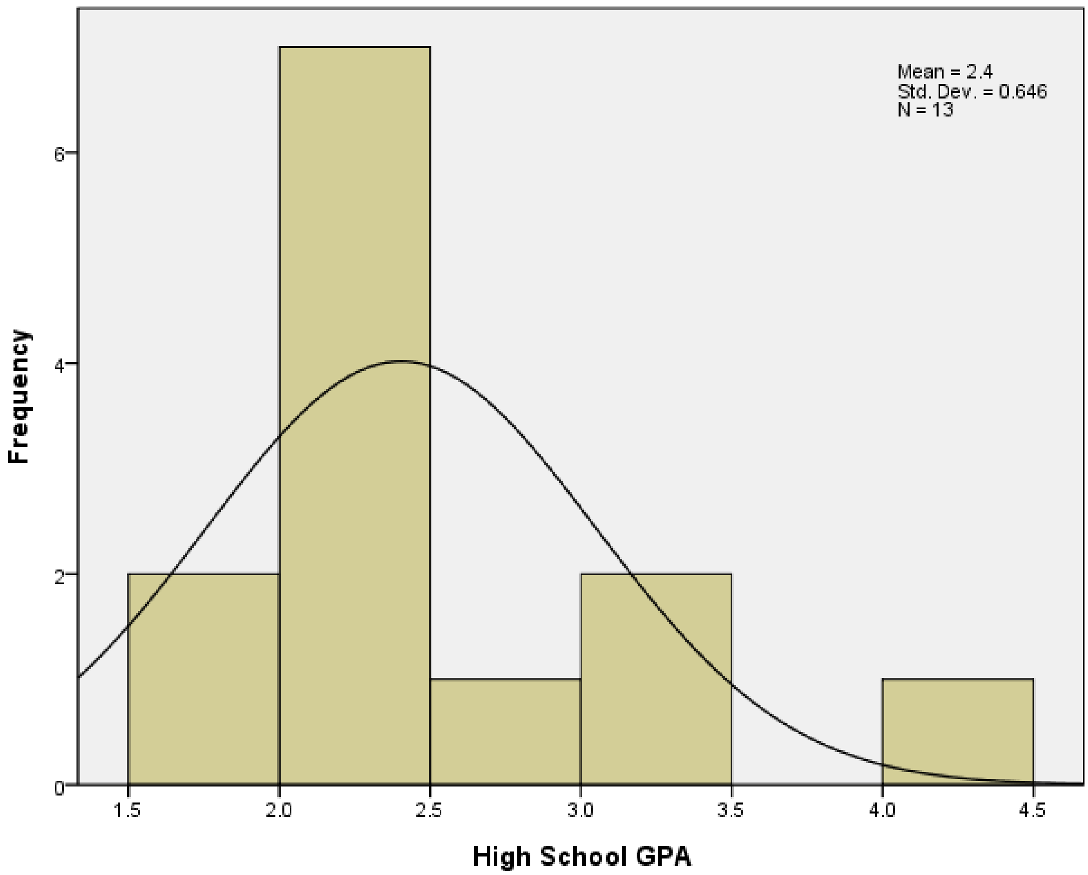


Figure 6.8 Control Group: HSGPA Histogram

<u>6.2.2.3 Student Gender</u>

In the Control Group, Table 6.11 indicates that the surveying profession is dominated by males. In this case, 96.1% males and 3.9% females are represented.

Table 6.11 Control Group Student Sex Breakdown

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	2	3.9	3.9	3.9
	Male	49	96.1	96.1	100.0
	Total	51	100.0	100.0	

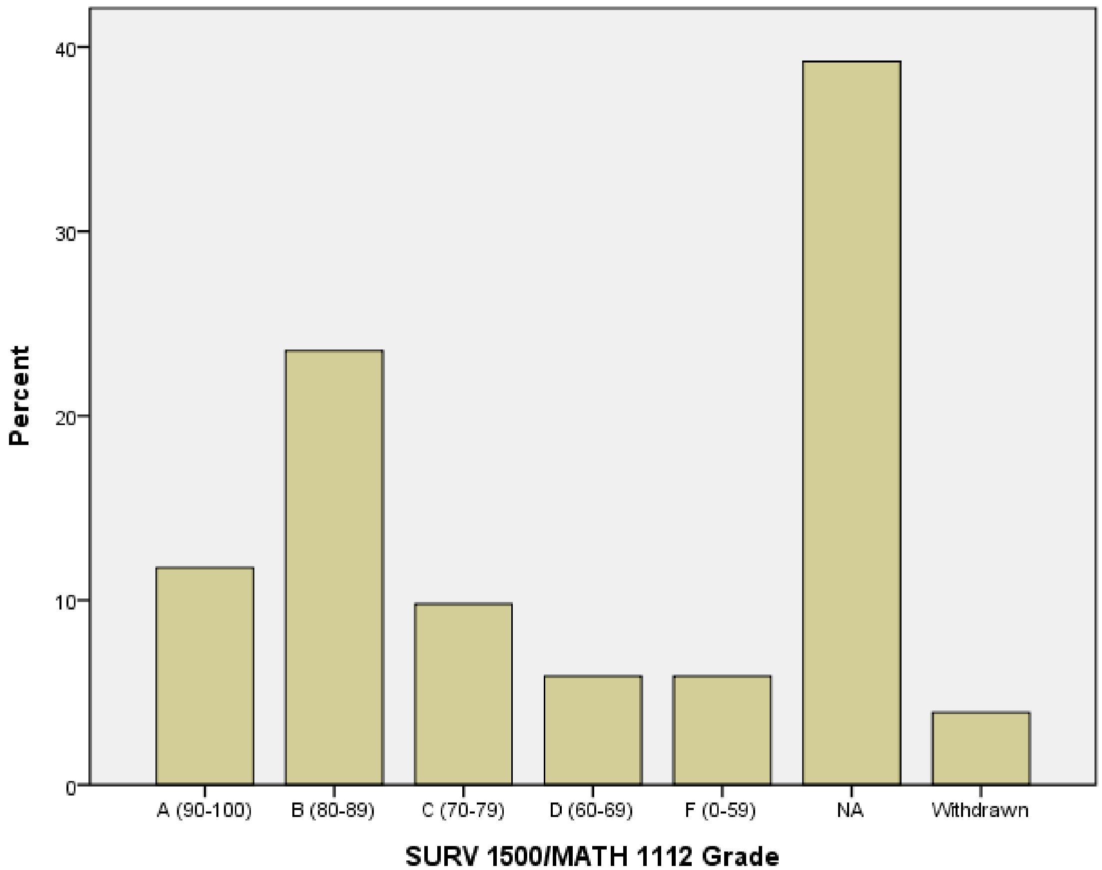
6.2.2.4 SURV 1500/MATH 1112 Grades

In the Control Group, the SURV 1500/MATH 1112 courses were provided to the s-g student to give the Math background necessary for the FSG course. Table 6.12 shows that the cumulative percentage for grades “C” and higher in these courses is 45.1%. This cumulative percentage for grades “C” and higher is an important factor since a grade of “D” or “F” in any of the MGSC s-g courses will cause the course to have to be repeated. The distribution seen in Figure 6.9 emphasizes a shift to the higher end of the grade range with the most prevalent grade being a “B” at 23.5%.

Table 6.12 Control Group: SURV 1500/MATH 1112 Grades

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A (90-100)	6	11.8	11.8	11.8
	B (80-89)	12	23.5	23.5	35.3
	C (70-79)	5	9.8	9.8	45.1
	D (60-69)	3	5.9	5.9	51.0
	F (0-59)	3	5.9	5.9	56.9
	NA	20	39.2	39.2	96.1
	Withdrawn	2	3.9	3.9	100.0
	Total	51	100.0	100.0	

NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.



NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.

Figure 6.9 Control Group: SURV 1500/MATH 1112 Grade Percentages

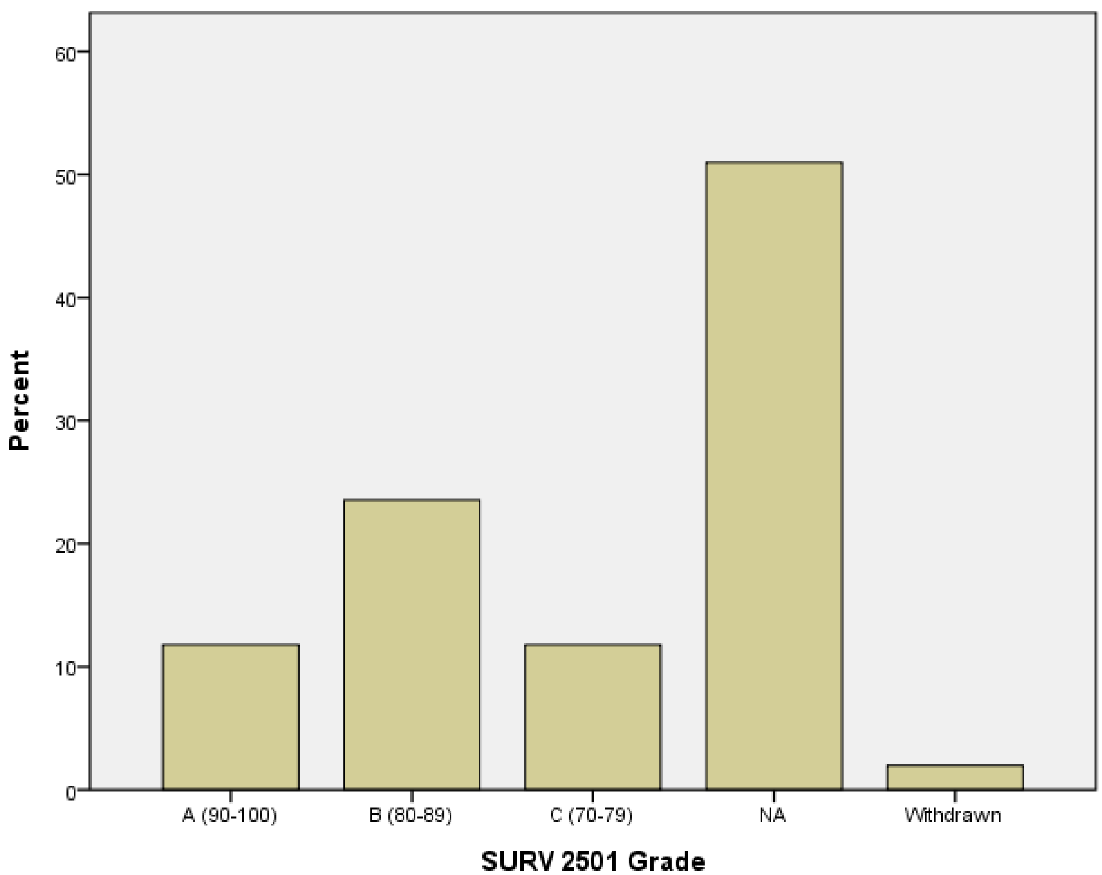
6.2.2.5 SURV 2501 Grades

Since SURV 2501 is the FSG course, for the Control group the cumulative percentage for grades of "C" and higher (for students attempting the course) is extremely important since a grade of "D" or "F" in any of the MGSC s-g courses will cause the course to have to be repeated. In the Control Group, Table 6.13 shows that this cumulative percentage is 47.1% which is 2 points higher than the SURV1500/MATH 1112 percentage. The grade distribution shown in Figure 6.10 indicates that the "B" grade is the most common at 23.5%.

Table 6.13 Control Group: SURV 2501 Grades

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A (90-100)	6	11.8	11.8	11.8
	B (80-89)	12	23.5	23.5	35.3
	C (70-79)	6	11.8	11.8	47.1
	NA	26	51.0	51.0	98.0
	Withdrawn	1	2.0	2.0	100.0
	Total	51	100.0	100.0	

NA: Denotes that the student was not required to take this course due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.



NA: Denotes that the student was not required to take this course due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.

Figure 6.10 Control Group: SURV 2501 Grade Percentages

6.2.2.6 Institution Cumulative Credit Hours

The Institution Cumulative Credit Hours (ICCH) represents the sum of the student's course credit hours obtained at MGSC. As shown in Table 6.14, the average ICCH for the Control Group is 13.69 hours which represents the average accumulated hours at the data query date of January 14, 2014. This average represents an equivalent of approximately 4.5 @ 3 hour academic courses. Zero values for the ICCH indicates that the s-g student was probably not successful in either SURV 1500 or Math 1112 and basically dropped from the s-g program. The percentage evaluation in Figure 6.11 indicates that 15.7% or 8 students had an ICCH of zero.

Table 6.14 Control Group: Institution Cumulative Credit Hours

N	Valid	51
	Missing	0
Mean		13.69
Median		9.00
Mode		0[a]
Std. Deviation		17.949
Range		111
Minimum		0
Maximum		111
Percentiles	25	3.00
	50	9.00
	75	21.00

a. Multiple modes exist. The smallest value is shown

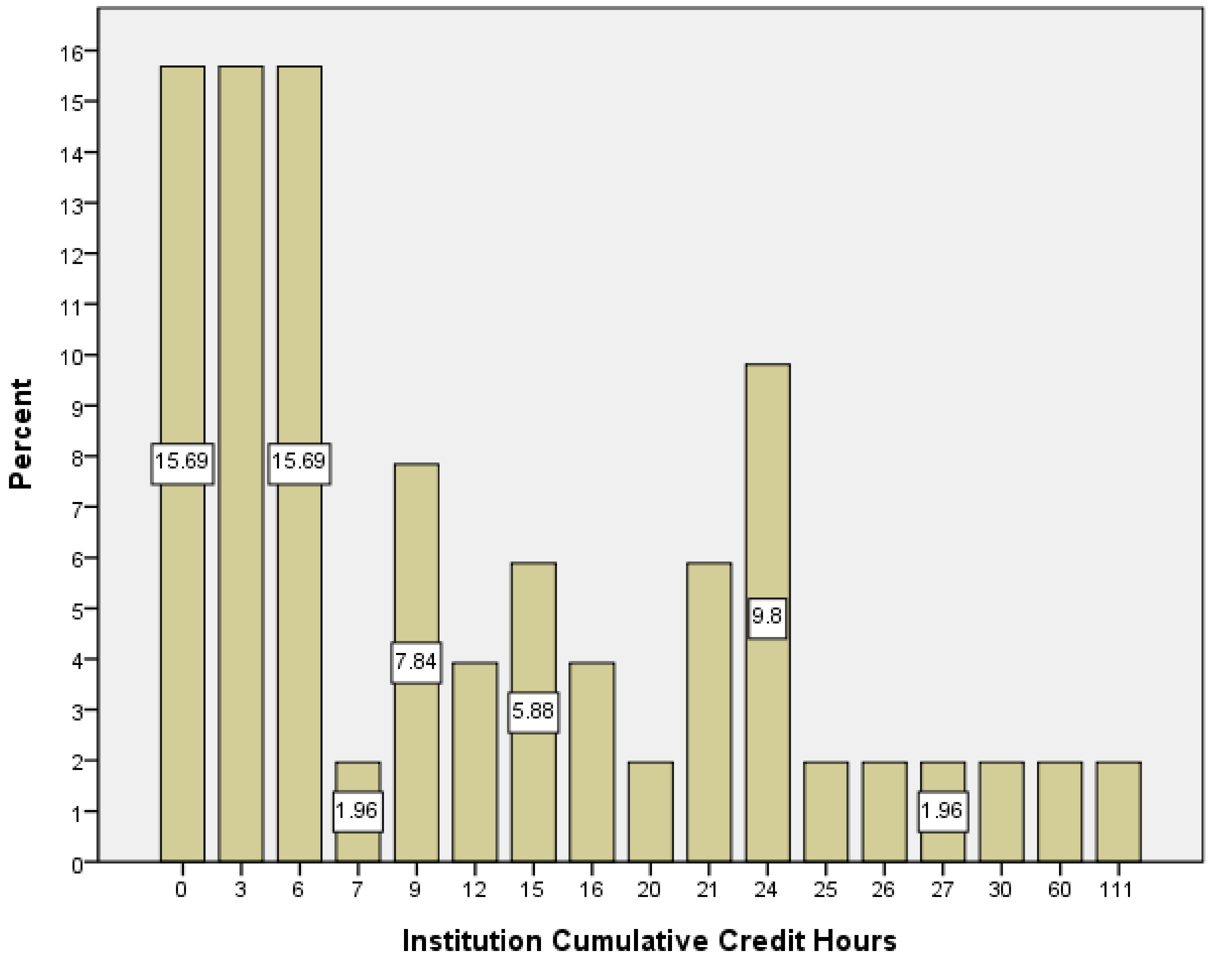


Figure 6.11 Control Group: Institution Cumulative Credit Hours

6.2.2.7 Student Institution Grade Point Average

As shown in Table 6.15 for the Control Group, the Institution Grade Point Average (IGPA) for reporting students is 2.31 out of 4.0 which is slightly lower than the HSGPA at 2.40 out of 4.0. The frequency of the GPA distribution is shown in Figure 6.12 where most of the grades were higher than the 2.0 category. Zero values for the IGPA indicates that the s-g student was probably not successful in either SURV 1500 or Math 1112 and basically dropped from the s-g program. The percentage evaluation in Figure 6.12 indicates that 8 students (15.6%) had an IGPA of zero.

Table 6.15 Control Group: IGPA Statistics

N	Valid	51
	Missing	0
Mean		2.314
Median		2.600
Mode		.0
Std. Deviation		1.2694
Range		4.0
Minimum		.0
Maximum		4.0
Percentiles	25	1.444
	50	2.600
	75	3.250

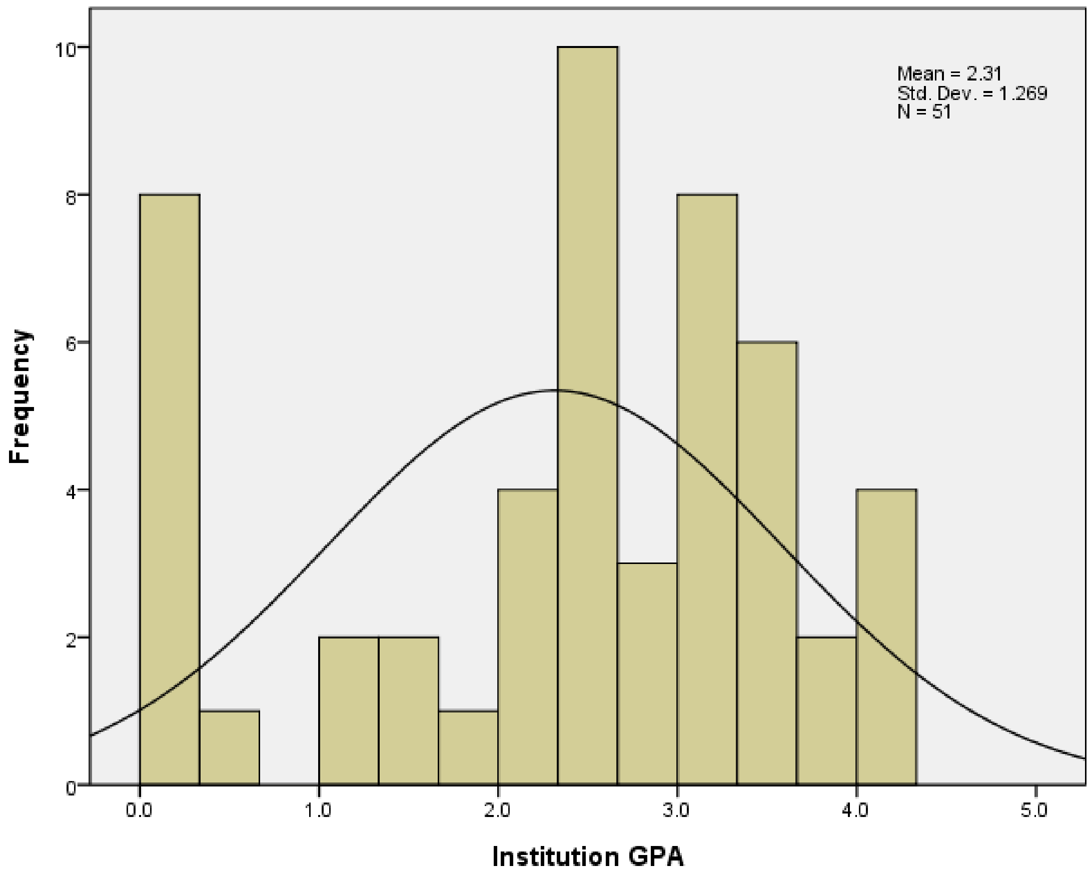


Figure 6.12 Control Group IGPA Distribution

6.2.3 Student Characterization: The Experimental Group

6.2.3.1 Student Age

As can be seen in the Table 6.16, the average student age for the Experimental Group is 33.8 years. The total age range is 25.0 – 53.1 years while the range between the 10 and 90 percentile averages is 26.0 – 45.7 years. Getting younger students to take s-g courses is important for the future of the surveying profession where the mean age of the surveying professional is in the mid to late 50s. Figure 6.13 shows that the distribution of students is shifted slightly to the youthful side of the mean.

Table 6.16 Experimental Group: Student-Age Statistics

N	Valid	21
	Missing	0
Mean		33.765
Median		31.776
Mode		25.0[a]
Std. Deviation		7.6024
Range		28.1
Minimum		25.0
Maximum		53.1
Percentiles	10	25.984
	90	45.653

a. Multiple modes exist. The smallest value is shown

Figure 6.13 Experimental Group: Student Age Histogram

6.2.3.2 High School Grade Point Average

As can be seen in Table 6.17, the average High School Grade Point Average (HSGPA) for the Experimental Group is 2.3 which is lower than might be expected when compared to students in face-to-face programs where the entrance requirements would be higher. As an example, the HSGPA requirement for entering freshman at Southern Polytechnic State University (The only other University System of Georgia institution offering s-g courses) is 2.5. (Anon., "Freshman Admissions", http://www.spsu.edu/undergraduate/admission/freshman.htm, accessed March 24, 2014) Additionally, many of the GPA records are missing from the overall group which is expected since many of the students may not have been required to provide their HSGPA at admission to MGSC. The mean reflects only the students that provided their HSGPA. Thus, approximately 14.2% of the population is represented.

Table 6.17 Experimental Group: HSGPA Statistics

N	Valid	3
	Missing	18
Mean		2.303
Median		2.470
Std. Deviation		.7932
Range		1.6
Minimum		1.4
Maximum		3.0

6.2.3.3 Student Gender

In the Experimental Group, Table 6.18 indicates that the surveying profession is dominated by males. In this case, 95.2% males and 4.8% females are represented.

Table 6.18 Experimental Group: Student Sex Breakdown

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	1	4.8	4.8	4.8
	Male	20	95.2	95.2	100.0
	Total	21	100.0	100.0	

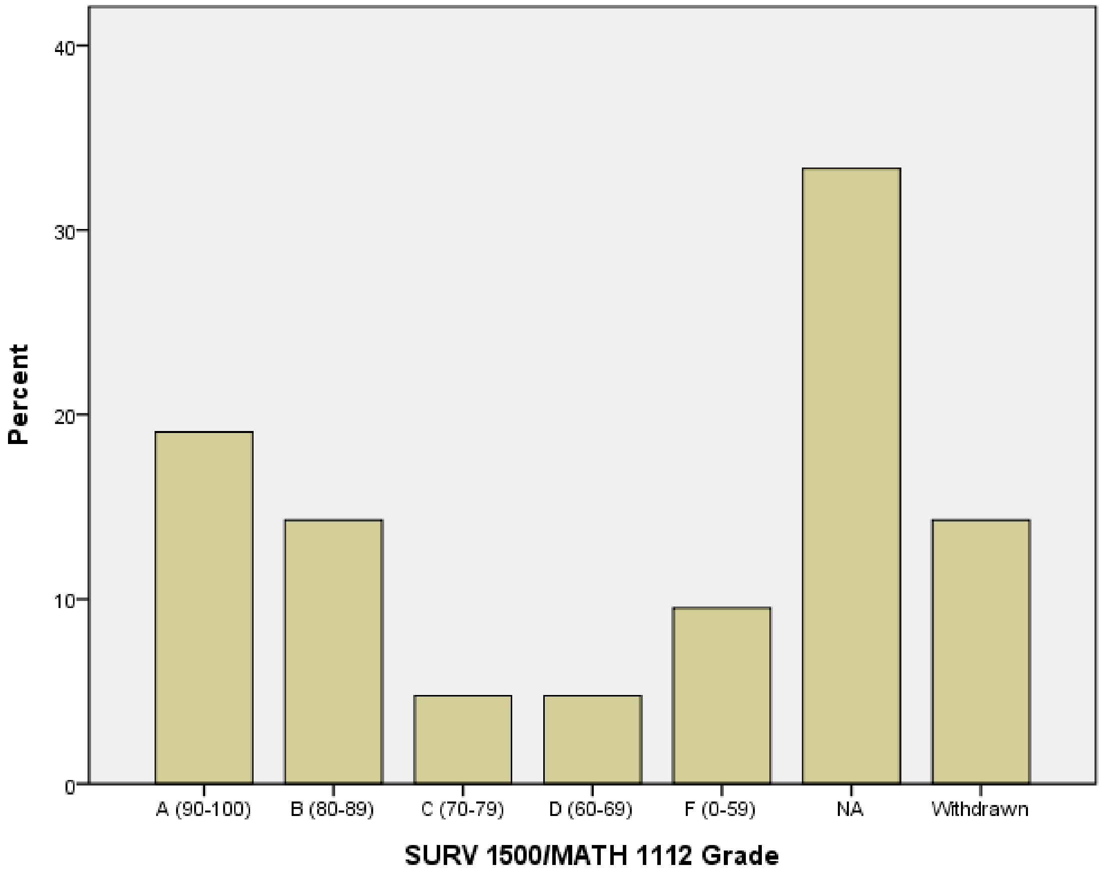
6.2.3.4 SURV 1500/MATH 1112 Grades

In the Experimental Group, the SURV 1500/MATH 1112 courses were provided to the s-g student to give the Math background necessary for the FSG course. Table 6.19 shows that the cumulative percentage for grades "C" and higher in these courses is 38.1%. This cumulative percentage for grades "C" and higher is an important factor since a grade of "D" or "F" in any of the MGSC s-g courses will cause the course to have to be repeated. The distribution seen in Figure 6.14 emphasizes a shift to the higher end of the grade range with the most prevalent grade being a "A" at 19.0%.

Table 6.19 Experimental Group: SURV 1500/MATH 1112 Grades

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A (90-100)	4	19.0	19.0	19.0
	B (80-89)	3	14.3	14.3	33.3
	C (70-79)	1	4.8	4.8	38.1
	D (60-69)	1	4.8	4.8	42.9
	F (0-59)	2	9.5	9.5	52.4
	NA	7	33.3	33.3	85.7
	Withdrawn	3	14.3	14.3	100.0
	Total	21	100.0	100.0	

NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.



NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.

Figure 6.14 Experimental Group: SURV 1500/MATH 1112 Grade Distribution

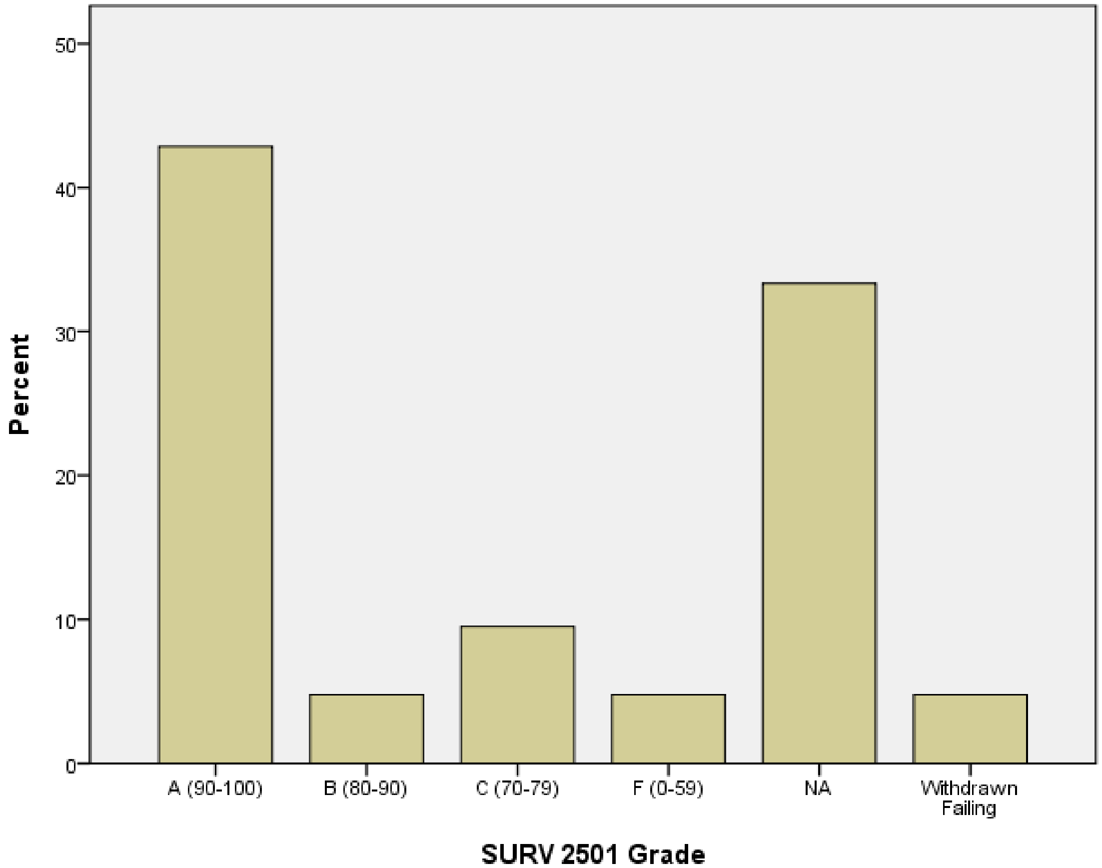
6.2.3.5 SURV 2501 Grades

Since SURV 2501 is the FSG course, for the Experimental group the cumulative percentage for grades of "C" and higher (for students attempting the course) is extremely important since a grade of "D" or "F" in any of the MGSC s-g courses will cause the course to have to be repeated. In the Experimental Group, Table 6.20 shows that this cumulative percentage is 57.1% which is 19 points higher than the SURV1500/MATH 1112 percentage. The grade distribution shown in Figure 6.15 indicates that the “A” grade is the most common at 42.9%.

Table 6.20 Experimental Group: SURV 2501 Grades

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A (90-100)	9	42.9	42.9	42.9
	B (80-90)	1	4.8	4.8	47.6
	C (70-79)	2	9.5	9.5	57.1
	F (0-59)	1	4.8	4.8	61.9
	NA	7	33.3	33.3	95.2
	Withdrawn Failing	1	4.8	4.8	100.0
	Total	21	100.0	100.0	

NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.



NA: Denotes that the student was not required to take either of these courses due to previous completion of an acceptable substitute course or the student was already licensed as a Land Surveyor in Training or a Professional Surveyor.

Figure 6.15 Experimental Group: SURV 2501 Grade Distribution

6.2.3.6 Institution Cumulative Credit Hours

The Institution Cumulative Credit Hours (ICCH) represents the sum of the student's course credit hours obtained at MGSC. As shown in Table 6.21, the average ICCH for the Experimental Group is 6.71 hours which represents the average accumulated hours at the data query date of January 14, 2014. This average represents an equivalent of approximately 2+ @ 3 hour academic courses. Zero values for the ICCH indicates that the s-g student was probably not successful in either SURV 1500 or Math 1112 and basically dropped from the s-g program. The percentage evaluation in Figure 6.16 indicates that 33.3% or 7 students had an ICCH of zero.

Table 6.21 Experimental Group: Institution Cumulative Credit Hours

N	Valid	21
	Missing	0
Mean		6.71
Median		6.00
Mode		0
Std. Deviation		6.634
Range		21
Minimum		0
Maximum		21
Percentiles	25	.00
	50	6.00
	75	12.00

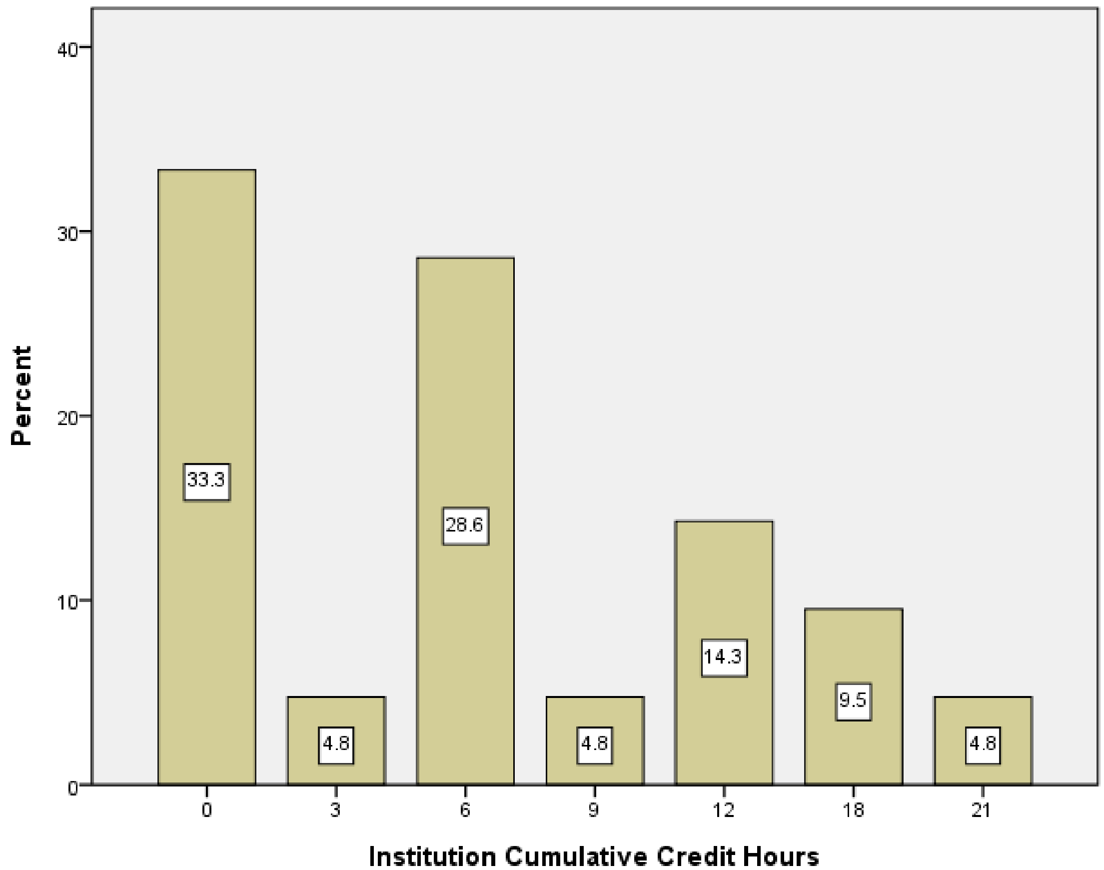


Figure 6.16: Experimental Group: Institution Cumulative Credit Hours

6.2.3.7 Student Institution Grade Point Average

As shown in Table 6.22 for the Experimental Group, the Institution Grade Point Average (IGPA) for reporting students is 2.18 out of 4.0 which is slightly lower than the HSGPA at 2.3 out of 4.0. The frequency of the GPA distribution is shown in Figure 6.17 where more than one half of the grades were equal to or greater than the 2.0 category. Zero values for the IGPA indicates that the s-g student was probably not successful in either SURV 1500 or Math 1112 and basically dropped from the s-g program. The percentage evaluation in Figure 6.17 indicates that 33.3% or 7 students had an IGPA of zero.

Table 6.22 Experimental Group: IGPA Statistics

N	Valid	21
	Missing	0
Mean		2.181
Median		3.000
Mode		.0
Std. Deviation		1.7785
Range		4.0
Minimum		.0
Maximum		4.0
Percentiles	25	.000
	50	3.000
	75	4.000

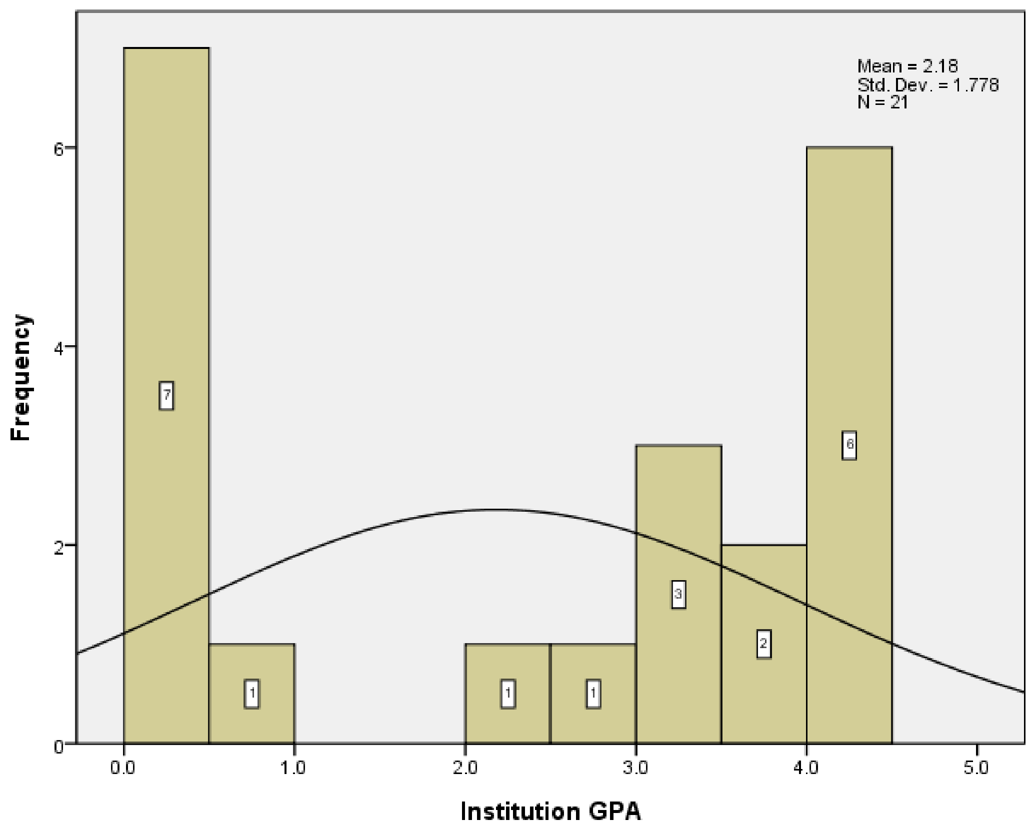


Figure 6.17 Experimental Group: IGPA Distribution

6.3 Comparison of Student Characterization Variables:

6.3.1 Student Characterization: Variable Breakdown

The breakdown of the student characterization variables is provided in Table 6.23 for the three variable groups: Introductory, Control and Experimental as given below.

Table 6.23 Group by Group Analysis of Student Characterization Variables

Variable Name	Introductory Group	Control Group	Experimental Group
Student Age (years)	32	33.8	33.8
High School Grade Point Average (0.0 – 4.0)	2.35	2.4	2.3
Student Sex (Male Gender %)	95.3	96.1	95.2
SURV 1500/MATH 1112 Grades (A+B+C %)	60.4	45.1	38.1
SURV 2501 Grades (A+B+C %)	51.4	47.1	57.1
Institution Cumulative Credit Hours	12.3	13.7	6.7
Institution Grade Point Average	2.37	2.31	2.18

Based on the descriptive statistical examination of the variables provided by the Banner database, all three of the data groups: Introductory, Control and Experimental have similar values for the Student Age, High School Grade Point Average, Student Sex and the Institution Grade Point Average variables. The two Grades variables: SURV 1500/MATH1112 Grades

(A+B+C %) & SURV 2501 Grades (A+B+C %) and the Institution Cumulative Credit Hours are quite different across the three groups. The SURV 1500/MATH1112 Grades (A+B+C %) variable maybe influenced by the variability of the students' ability to adapt to college level courses and academics in general since the majority of these students are nontraditional students far removed from high school. The variation in the averages for the Institutional Cumulative Credit Hours may be resulting from the students' position in the program at the time the data was taken. The variation in the SURV 2501 Grades (A+B+C%) variables maybe influenced by many variables including the student pre-course academic preparation and the experimental treatment provided for the Experimental Group as given in this study.

The graphical representation provided for the Pre-Institution Characterization Variables in Figure 6.18 emphasizes the similarity in these variables including: Student Age, High School GPA and Male Gender Percentage.

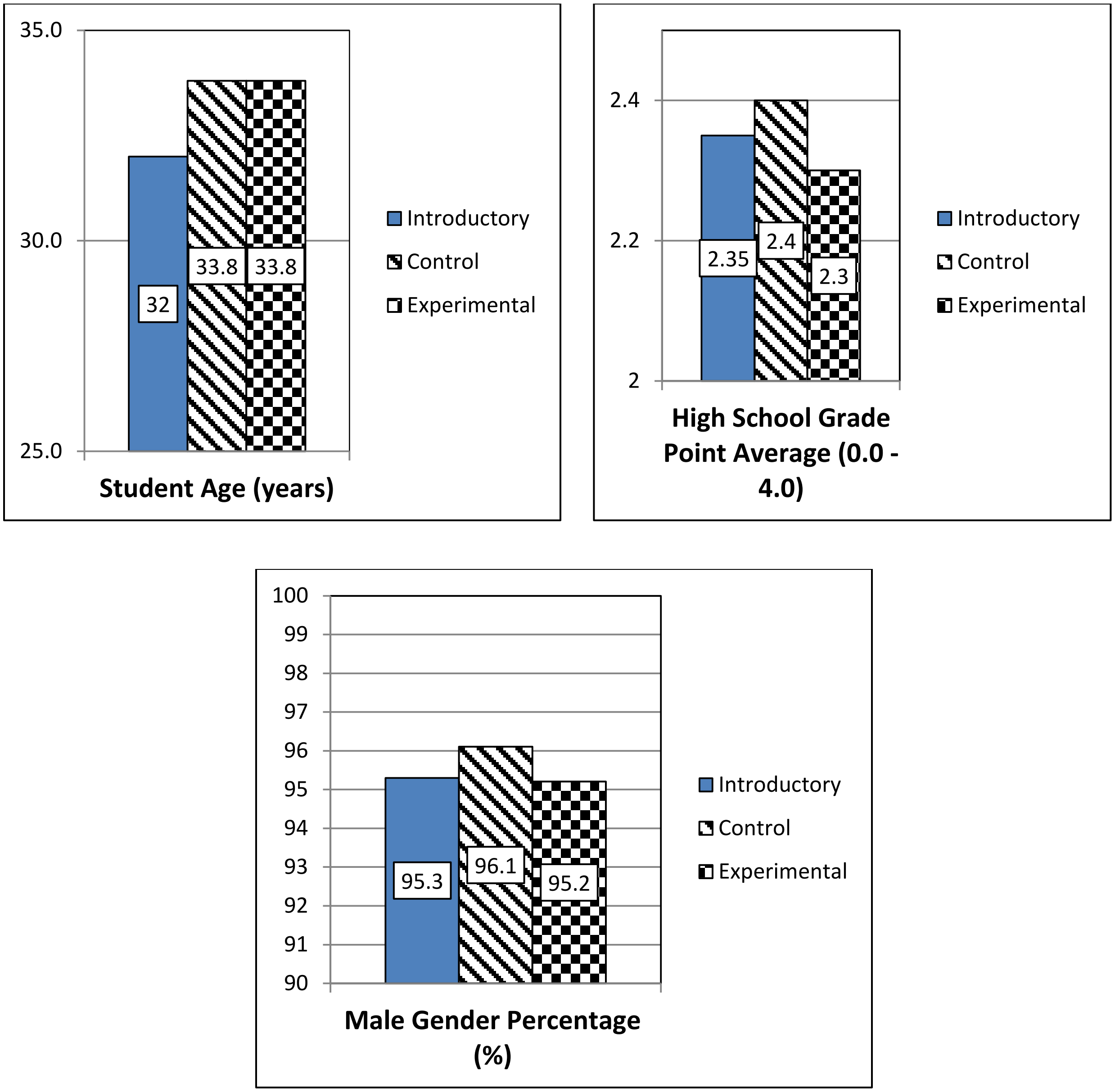


Figure 6.18 A, B, C: Pre-Institution Student Characterization Variables

Figure 6.19 illustrates the cumulative percentage of A, B & C grades in the SURV 1500/MATH1112 and SURV 2501 courses. It is apparent that this indicator for the SURV 1500/MATH1112 course was declining from the introductory period through the experimental period while this indicator for the SURV 2501 courses increased in the Experimental Period.

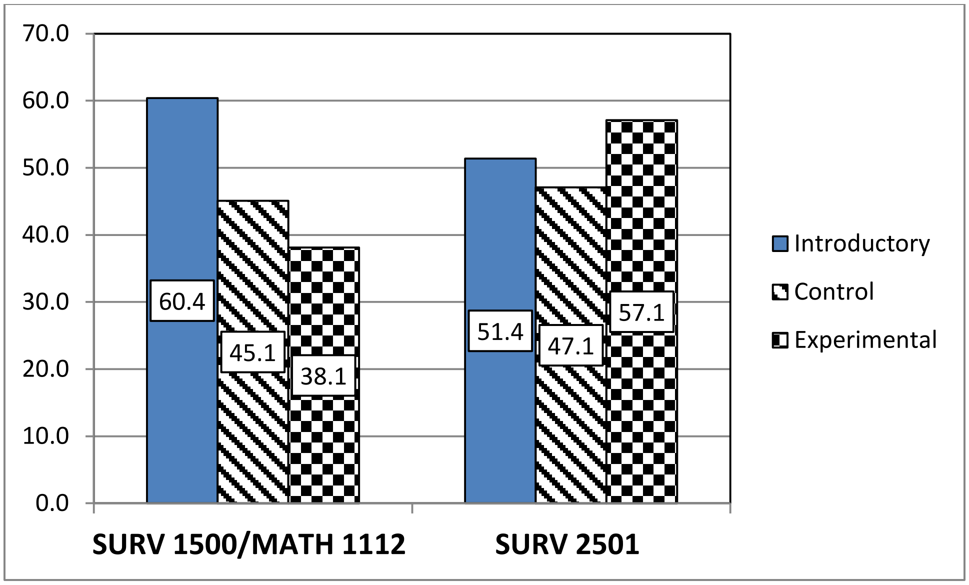


Figure 6.19 Cumulative Percent of A+B+C Grades in Courses

Additionally, the SURV 1500/MATH1112 and the SURV 2501 Grades were evaluated on an average course GPA basis. The results are given in Figure 6.20 below and indicate the uniformity of GPA score for all three groups in the SURV 1500/MATH1112 course while the SURV 2501 Grades show that the GPA is trending upward from 2.4 to 3.1 across the three groups.

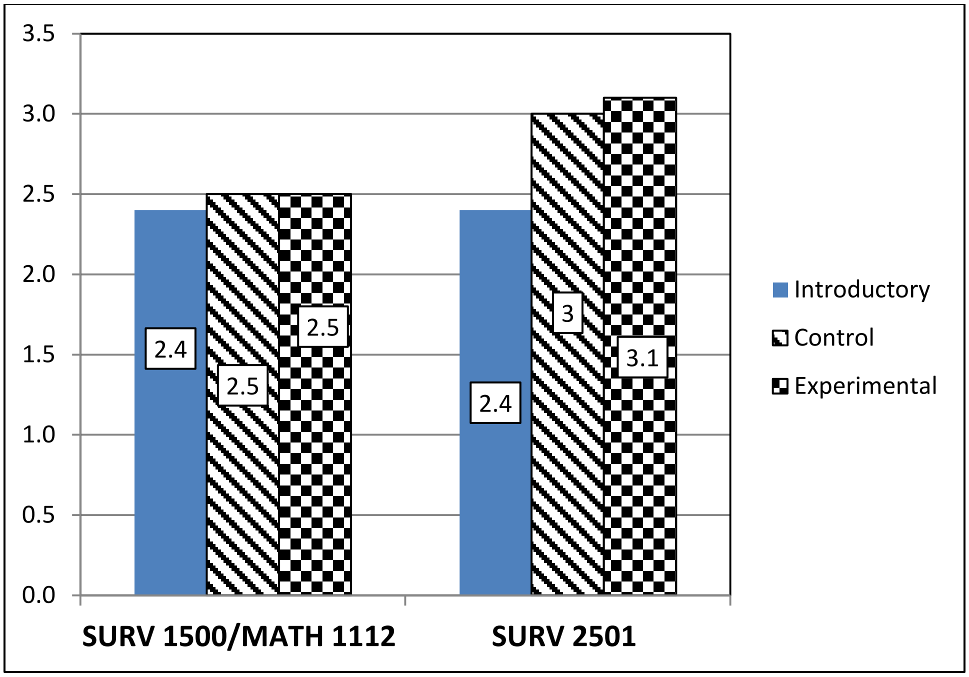


Figure 6.20 S-G Course Grade Point Averages (based on course grade quality points)

6.3.2 Student Characterization: Variable Significance

The four scale variables: Student Age, High School Grade Point Average, Institution Cumulative Credit Hours and Institution Grade Point Average were evaluated for significance and to determine if their means were equal across the three data groups. An Analysis of Variance (ANOVA) was performed and the results are given in Tables 6.24 and 6.25. In Table 6.24, the F factor which represents the ratio of the Mean Squares based on the Sum of Squares between groups and within groups was not close to one and the corresponding Significance was greater than five times in a hundred in every case. Thus, the Null Hypothesis that indicates that he means of the four variables: Student Age, High School GPA, Institution GPA and Institution Cumulative Credit Hours are equal cannot be rejected.

Table 6.24 Analysis of Variance for Characterization Variables across three Time Period Groups: Introductory, Control and Experimental

		Sum of Squares	df	Mean Square	F	Sig.
Age in Years	Between Groups	205.230	2	102.615	1.158	.315
	Within Groups	57338.037	647	88.621		
	Total	57543.267	649			
High School GPA	Between Groups	.044	2	.022	.070	.932
	Within Groups	44.284	140	.316		
	Total	44.328	142			
Institution GPA	Between Groups	.840	2	.420	.255	.775
	Within Groups	1065.562	647	1.647		
	Total	1066.402	649			
Institution Cumulative Credit Hours	Between Groups	747.710	2	373.855	2.752	.065
	Within Groups	87890.076	647	135.842		
	Total	88637.786	649			

Likewise, to identify where statistically significant differences were, we performed a Bonferroni comparison on all of the variables against all of the combinations of the time periods. The results in Table 6.25 indicate that all of the groups differ according to the F factor (Ratio of the Mean Square) and no variable indicated a significance smaller than 0.05. Thus, the Null Hypothesis that indicates that the means of the four variables: Student Age, High School GPA, Institution GPA and Institution Cumulative Credit Hours are equal cannot be rejected. These variables will be used in additional analysis later in this study.

Table 6.25 Analysis of Variance for Characterization Variables

Multiple Comparisons							
Bonferroni							
Dependent Variable	(I) Time Period	(J) Time Period	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Age in Years	Introductory	Control	-1.8003	1.3751	.573	-5.101	1.500
		Experimental	-1.7661	2.0913	1.000	-6.786	3.253
	Control	Introductory	1.8003	1.3751	.573	-1.500	5.101
		Experimental	.0342	2.4408	1.000	-5.824	5.893
	Experimental	Introductory	1.7661	2.0913	1.000	-3.253	6.786
		Control	-.0342	2.4408	1.000	-5.893	5.824
High School GPA	Introductory	Control	-.0538	.1638	1.000	-.451	.343
		Experimental	.0539	.3285	1.000	-.742	.850
	Control	Introductory	.0538	.1638	1.000	-.343	.451
		Experimental	.1077	.3602	1.000	-.765	.981
	Experimental	Introductory	-.0539	.3285	1.000	-.850	.742
		Control	-.1077	.3602	1.000	-.981	.765
Institution GPA	Introductory	Control	.0538	.1875	1.000	-.396	.504
		Experimental	.1905	.2851	1.000	-.494	.875
	Control	Introductory	-.0538	.1875	1.000	-.504	.396
		Experimental	.1367	.3327	1.000	-.662	.935
	Experimental	Introductory	-.1905	.2851	1.000	-.875	.494
		Control	-.1367	.3327	1.000	-.935	.662
Institution Cumulative Credit Hours	Introductory	Control	-1.413	1.703	1.000	-5.50	2.67
		Experimental	5.559	2.589	.096	-.66	11.77
	Control	Introductory	1.413	1.703	1.000	-2.67	5.50
		Experimental	6.972	3.022	.064	-.28	14.23
	Experimental	Introductory	-5.559	2.589	.096	-11.77	.66
		Control	-6.972	3.022	.064	-14.23	.28

CHAPTER 7

STUDENT ACADEMIC PERFORMANCE

In this study, student academic performance analysis was based on a comparison of course data taken from FSG course offerings with the application of "assessment for learning" (experimental assessment) methods versus data taken from FSG course offerings with the application of "assessment of learning" (control assessment) methods. Thus, student learning was measured by academic performance as determined from the analysis of the student performance on two metrics: Common Quiz Questions (CQQ) and the Final Exam (FE or control test). This analysis includes the following elements: an examination of student performance on the quizzes that contain the two metrics, and a comparison of performance on these two metrics themselves. (As an example of FSG academic performance prediction, an examination of pre-institution/institution variables versus FSG academic performance variables and CQQ performance versus FSG academic performance variables is provided in Appendix D of this study.)

7.1 An Examination of Student performance on Unit Quizzes-Module Quizzes and the Final Exam

As cited above, the Unit Tests-Module Quizzes and Final Exams were examined to determine the uniformity of the student performance and to see if the performance improved between the control course offerings and the experimental course offerings.

7.1.1 Unit Tests – Module Quizzes

As a beginning point, the subject coverage of the Unit Tests versus the Module Quizzes should be examined. As can be seen below in Table 7.1, the coverage of the Unit Tests run generally parallel with the Module Quizzes where the Unit Tests cover two chapters in the case of Units 1, 4, 5, 6 and 7. In the case of Units 2 and 8 which correspond to Module Quizzes 15 and 8, only one chapter is covered. The only difference in the progressive order of chapter coverage was the location of chapter 3 where chapter 3 was inserted in consecutive order in the Unit Test Group while being inserted at the end of the Module Quiz group.

Table 7.1 Course Coverage Equivalency Table

Textbook Chapter Coverage	Unit Test #	Module Quiz #
1. Surveying introduction	1	1
2. Units, Significant Figures & Field Notes	1	2
3. Errors in Surveying	2	15
4. Leveling -Theory, Methods & Equipment	3	3
5. Leveling – Field Procedures & Computations	4	4
6. Distance Measurement	4	5
7. Azimuths, Angles & bearings	5	6
8. Total Station Angle Measurements	5	7
9. Traversing	6	9
10. Traverse Computations	6	10
11. Coordinate Geometry	7	11
12. Area Calculations	7	12
13. GPS Introduction	8	14

Unit tests typically contained 20 multiple-choice problems with an allowable test time of 2 hours. Multiple-choice problems and answers were designed to require an exact solution to the problem by the student. Guessing of problem answers was inherently discouraged. Module Quizzes contained a varying number of questions depending on the material coverage. The maximum number of questions was 20 and this number occurred in the earlier modules with the later modules having as few as 5 questions where the material called for extensive calculations in each question. The students were allowed one hour to take the module quizzes.

The breakdown of the Unit Test performance across the control course offerings can be seen in Table 7.2 below. There were 52 test takers with no missing data and the scores varied between zero and 100 across the Unit Test summaries. The variability of the means of the Unit Tests can be seen in Figure 7.1 as well. It was apparent that there was a large drop in scores (26.3 points) at the Unit 4 Test which may suggest that students have difficulty with Chapters 5 & 6 of the text.

Table 7.2 Unit Test Statistics (Control)

		Quiz 01	Quiz 02	Quiz 03	Quiz 04	Quiz 05	Quiz 06	Quiz 07	Quiz 08
N	Valid	52	52	52	52	52	52	52	52
	Missing	0	0	0	0	0	0	0	0
Mean		85.87	89.52	92.69	66.44	73.46	82.21	75.38	79.71
Median		85.00	95.00	95.00	70.00	75.00	85.00	80.00	85.00
Mode		100	100	95	70	65	90	95	85[a]
Std. Deviation		12.669	12.651	7.034	18.822	18.002	15.793	20.624	24.059
Range		50	50	35	85	75	75	100	100
Minimum		50	50	65	15	25	25	0	0
Maximum		100	100	100	100	100	100	100	100
Percentiles	10	66.50	66.50	85.00	41.50	48.00	61.50	50.00	49.50
	90	100.00	100.00	100.00	90.00	95.00	100.00	95.00	100.00

a. Multiple modes exist. The smallest value is shown

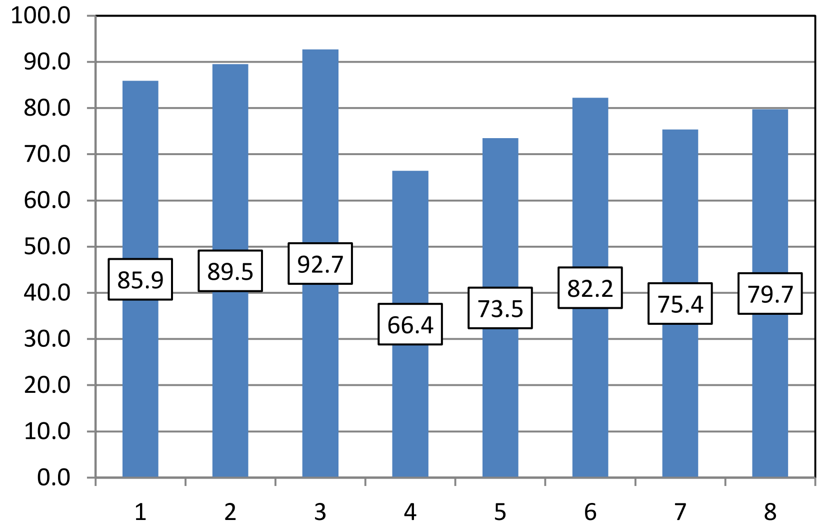


Figure 7.1 Averages of Unit Test Scores (Control)

The Module Quiz performance across the experimental course offerings can be seen in Table 7.3 below. There were 17 test takers with no missing data and the scores varied between zero and 100 across the Module Quiz summaries. The variability of the means of the Module Quiz Averages can be seen in Figure 7.2 as well. It is apparent that the variation across the modules did not fluctuate as much as the Unit Test score averages with the largest module to module variation, 10 points, occurring between Modules 7 and 9.

Table 7.3 Module Quiz Statistics (Experimental)

		MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ9	MQ10	MQ11	MQ12	MQ14	MQ15
N	Valid	17	17	17	17	17	17	17	17	17	17	17	17	17
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		95.29	90.88	86.47	82.35	87.94	91.70	83.20	93.21	87.10	94.13	92.94	86.29	88.75
Median		95.00	95.00	85.00	80.00	85.00	92.00	85.72	94.52	93.38	100.02	100.00	100.00	100.02
Mode		100	95	85	75[a]	85[a]	100	86	100	100	100	100	100	100
Std. Deviation		5.145	9.055	11.147	8.124	9.366	11.405	13.117	6.068	13.019	10.102	15.718	24.467	24.323
Range		15	30	45	30	30	33	43	17	40	33	60	100	68
Minimum		85	70	55	65	70	67	57	83	60	67	40	0	32
Maximum		100	100	100	95	100	100	100	100	100	100	100	100	100
Percentiles	10	85.00	74.00	71.00	73.00	74.00	66.70	62.86	83.40	65.37	80.02	72.00	53.34	33.04
	90	100.00	100.00	100.00	95.00	100.00	100.02	100.00	100.08	100.05	100.02	100.00	100.02	100.02

a. Multiple modes exist. The smallest value is shown

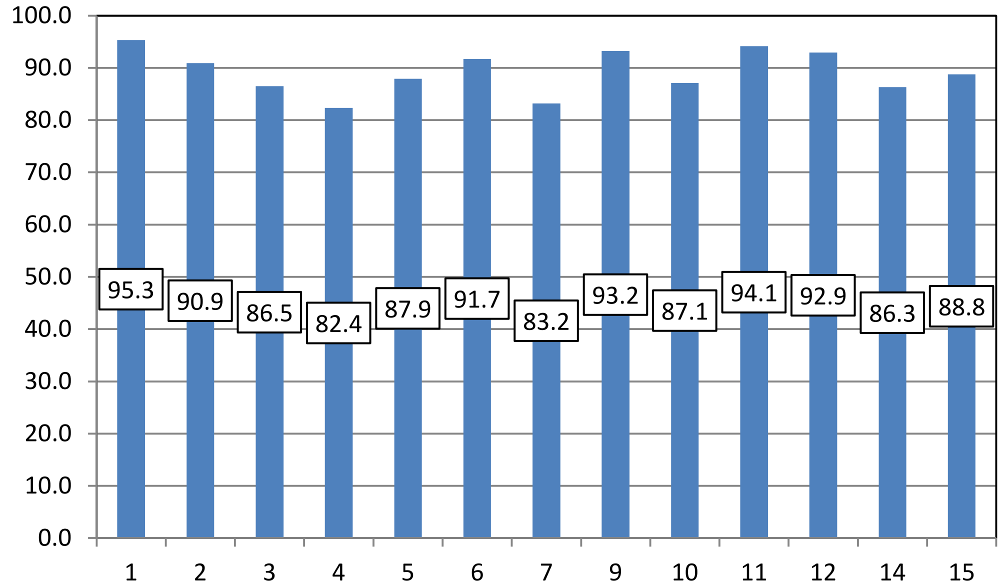


Figure 7.2 Averages of Module Quiz Scores (Experimental)

Finally, in Figure 7.3 below, a comparison of the average of the averages of the Unit Tests and Module Quizzes was provided. As shown, the average of the Module Quiz Averages was 89.3 points and exceeds the average of the Unit Test Averages (80.7 points) by 8.6 points.

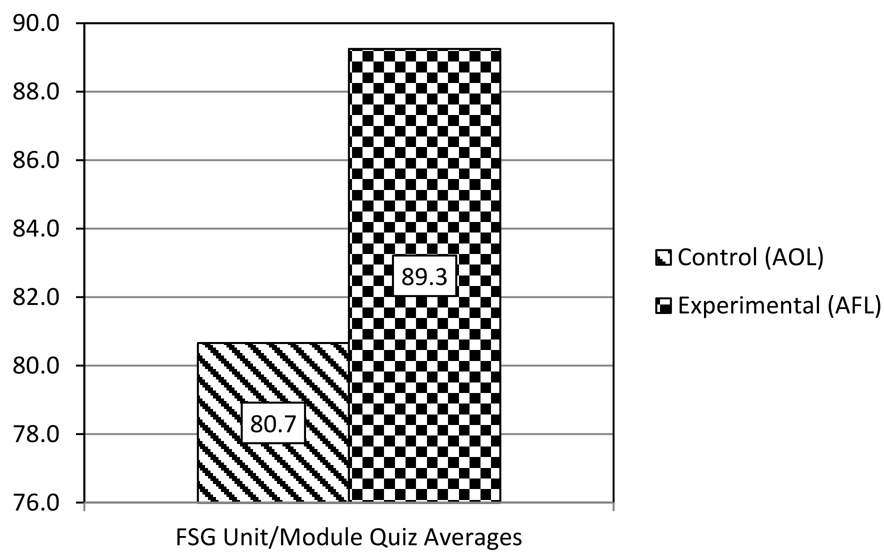


Figure 7.3 Comparison of Average of Average Unit Test Scores vs. Module Quizzes

7.1.1.1 Common Quiz Questions Analysis

As discussed in Chapter 3 of this study, a group of seventy-three representative common quiz questions (CQQ) was established as one of the metrics for measuring student learning in the FSG course. In order to utilize this question group for performance analysis, the following steps were performed:

- For the control course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2009, Summer 2010, Summer 2010, Fall 2010, Summer 2011, and Fall 2011 semesters.
- For the experimental course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2012, Spring 2013, Summer 2013 and Fall2013 semesters.

Table 7.4 Typical Common Quiz Question Aggregation

Quest. #	Question Title	Average Score	Out Of	%	Attempt s	Correct Attempts	% Correct
1	LM1-MQ1A Challenges 1	5	5	1	2	2	
1	LM1-MQ1A Challenges 1	3.33	5	0.6667	3	2	
1	LM1-MQ1A Challenges 1	3	5	60%	5	3	
1	LM1-MQ1A Challenges 1	5	5	1	10	10	
					20	17	85.0%
2	LM1-MQ1A Challenges 2	5	5	1	2	2	
2	LM1-MQ1A Challenges 2	5	5	1	3	3	
2	LM1-MQ1A Challenges 2	5	5	100%	5	5	
2	LM1-MQ1A Challenges 2	5	5	1	10	10	
					20	20	100.0%

As seen in Table 7.4 above, Common Quiz Question performance was aggregated and calculated for both the Control and Experimental courses in a similar way. Next, for each common quiz question, the difference in % correct was determined by subtracting the AOL % correct (control) from the AFL % correct (experimental). (Thus, a +% correct indicated an increase in % correct for a particular question.) An example of the + increase in % correct calculation is shown in Table 7.5.

Table 7.5 Typical Calculation of + Increase in % Correct (AFL – AOL)

Question Name	Title from Excel: Sum ()	Ch.	Ranking	"AFL" - "AOL" Act. % correct per ?	#
LM1-MQ1A Geo vs Plane 1	Sum (quiz01_003)	1	High	2.7	1.0
LM1-MQ1A Geo vs Plane 2	Sum (quiz01_004)	1	Low	6.7	2.0
LM1-MQ1A Special 1	Sum (quiz01_005)	1	High	0.0	3.0
LM1-MQ1A Special 2	Sum (quiz01_002)	1	Low	10.0	4.0
LM2-MQ2A SF 1	Sum (17)	2	High	-6.4	5.0

In order to evaluate the positive increase in the percentage correct of CQQs (Experimental minus Control) the following groups given in Table 7.6 were selected.

Table 7.6 Groupings for Analysis CQQ + Increase in % Correct

Group Number	Description
1	Question # and difference in % correct for the entire 73 question base
2	Grouping by percentile for Lower 25%, Middle 50% and Upper 75% CQQ Groups
3	Grouping by CQQ-AOL ranking: High, Medium and Low
4	Grouping by Subject Areas coordinated with CQQ
5	Grouping by High and Low Performance Analysis of CQQ

7.1.1.2 Common Quiz Questions Analysis Results

In the following sub-sections, the Groupings for Analysis of the CQQ + Increase in % Correct (Experimental – Control) will be examined.

7.1.1.2.1 The Entire Seventy-Three Common Quiz Question Base

The Entire Seventy-Three Common Quiz Question Base was summarized in Table 7.7 and indicates that the average increase in % correct for the Experimental Group (AFL) was +7.5%. Forty-eight (or 65.7%) of the individual common questions showed a positive increase. These increases were very important since they may be the result of the course treatment (AFL vs. AOL). Figure 7.4 indicates an approximate normal distribution of increase in % correct values with a large spike occurring at the 0 to 5% range.

Table 7.7 Analysis of "AFL"-"AOL" CQQ % Correct

N	Valid	73
	Missing	0
Mean		7.4644
Median		4.9000
Mode		.00[a]
Std. Deviation		13.11010
Range		59.00
Minimum		-20.50
Maximum		38.50
Percentiles	25	-1.3000
	50	4.9000
	75	17.1000
a. Multiple modes exist. The smallest value is shown		

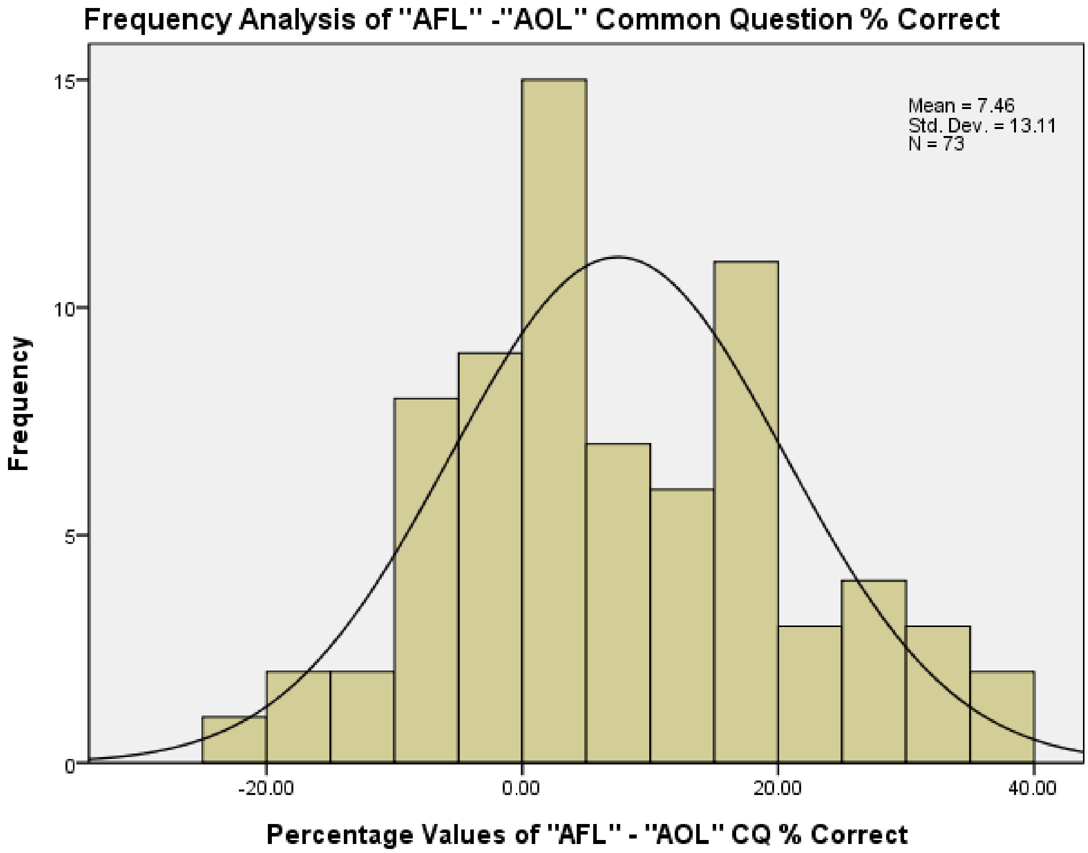


Figure 7.4 Percentage Values of "AFL" - "AOL" % Correct

7.1.1.2.2 Grouping by Percentile for the CQQ

From Table 7.7, the Percentile Breakdown of the increase in % correct (AFL-AOL) of CQQ was given as follows:

- <u>Lower 25%: -1.3%</u>
- <u>Middle 50%: +4.9%</u>
- <u>Upper 75%: +17.1%</u>

This analysis indicates that the upper 25% of the positive CQQ is performing at a much stronger positive rate than the lower 25% which is performing in the negative range. Also, the Middle 50% is showing an average of 4.9% which well into the positive range.

7.1.1.2.3 Grouping by CQQ-AOL ranking: High, Median and Low

Using the ranking analysis from the AOL question selection method the increase in % correct results were as follows: (See Table 7.8)

Table 7.8 Analysis of CQQ % Correct By Initial CQ Ranking

Initial CQ Ranking	High	Median	Low
# of Common Questions in Ranking	15	33	25
Average “AFL” – “AOL” % Correct	-3.4%	+6.5%	+15.3%

This table is significant since it shows that the average of the median and low rated groups' question % correct increases were much greater than the negative increase (decrease) of question % correct results reflected in the High rated group. Also, it shows that the performance reflected in the high rated group was not maintained by the treatment in the experimental courses.

7.1.1.2.4 Grouping by Subject Areas coordinated with CQQ

Based on a breakdown of the CQQ by Subject Area Groups which included a division of 38 subject areas, the high and low subject area groups were identified as follows:

- Highest % increase (average) – Subject Area: Leveling - Field Operation and Care Group: +37.8%
- Lowest % increase (average) – Subject Area: Problems applied to Errors in Surveying Group: -12.2%

Both of these subject areas are important for future study to see if any specific cause for these differing results can be tied to the treatment (or lack of treatment) in the experimental courses versus the control courses. A further breakdown by subject areas based on a positive or negative % correct increase gave the following results:

- Subject Area Groups with + % correct increase: 28 Groups or (73.7%)
- Subject Area Groups with a - % correct increase (decrease): 10 Groups or (26.3%)

7.1.1.2.5 Grouping by High and Low Performance Analysis of CQQ

The ten highest and the ten lowest performing CQQs in terms of % correct increase were grouped and selected for review. The average + % increase for the highest performing group was +30.1% while the average for the lowest performing group was -11.4%. The lowest performing group had only high (40%) and medium (60%) ranked questions based on the AOL selection analysis. The highest performing group had only low (80%) and medium (20%) ranked questions based on the AOL selection analysis. This analysis indicates the need for further investigation into the possible cause for the improvement of the performance on the lower ranked questions and into the possible cause for the lack of improvement in the high and medium questions.

7.1.2 Final Exam (Control Test)

Having reviewed the Unit Test-Module Quiz CQQ results, the Final Exam (Control Test) was reviewed based on the student performance. As discussed in the Assessment Development section of this study, 23 representative questions of the Final Exam were established as a metric for measuring summative student learning in the FSG course. In order to utilize these questions for analysis the following steps were performed:

- For the control course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2009, Summer 2010, Summer 2010, Fall 2010, Summer 2011, and Fall 2011 semesters.
- For the experimental course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2012, Spring 2013, Summer 2013 and Fall2013 semesters.
- For each student, the 23 representative questions were validated for the correct response and the % correct was determined. The % correct was averaged for both the control (AOL) and the experimental (AFL) groups. The difference in % correct was determined by subtracting the AOL % correct average (control) from the AFL % correct average (experimental).

7.1.2.1 Analysis of Final Exam (control test) Results

The student performance in the Final Exam (twenty-three question set) was summarized in Table 7.9 & Table 7.10 and indicates that the average increase in % correct for the Experimental Group (AFL) over the Control Group (AOL) was +12.61% (78.06% – 65.45%). Since the Final Exam was a summative assessment, this apparent increase in student performance is very important since the increase may be the result of the course treatment (AFL vs. AOL). A comparison of the 25, 50 and 75 percentiles of the two groups yielded the following results:

- Lower 25 Percentile: 68.23% - 50.55% = +17.68%
- Middle 50 Percentile: 82.05% - 69.60% = +12.45%
- Upper 75 Percentile: 82.60% - 77.75% = +4.85%

Thus, for each percentile average, the increase in % correct values was positive.

Table 7.9 Percent Correct of Control Test Question Group

N	Valid	33
	Missing	0
Mean		65.4545
Median		69.6000
Std. Deviation		14.64215
Range		56.50
Minimum		35.90
Maximum		92.40
Percentiles	25	50.5500
	50	69.6000
	75	77.7500

Table 7.10 Percent Correct of Experimental Test Question Group

N	Valid	16
	Missing	0
Mean		78.06
Median		82.05
Mode		83
Std. Deviation		12.476
Range		48
Minimum		52
Maximum		100
Percentiles	25	68.23
	50	82.05
	75	82.60

Additionally, Figures 7.5 & 7.6 indicate an approximate normal distribution of % correct values. In the Control Group, there is large spike at the 70% to 80% (% correct) range while in the Experimental Group; there is a spike at the 80% to 90% (% correct) range. Having the mean scores increase between the Control and Experimental Groups is important since it may indicate the positive impact of the experimental treatment provided.

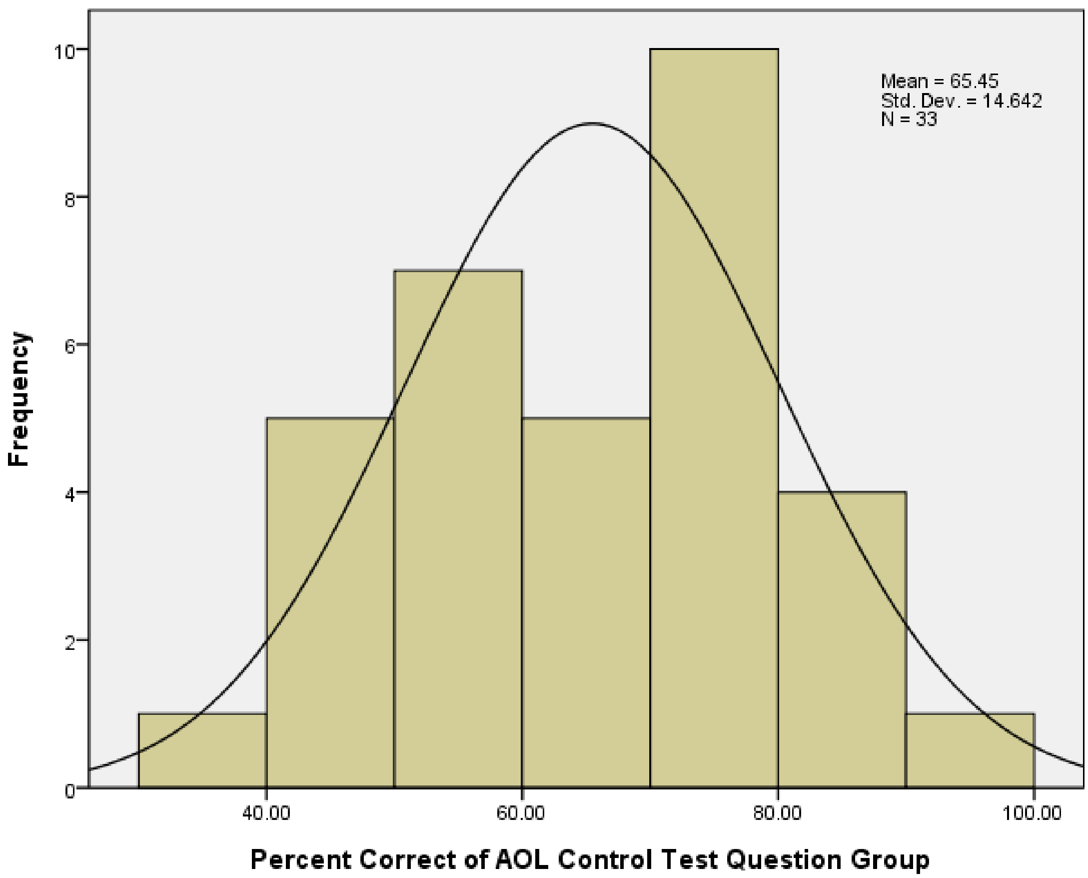


Figure 7.5 Histogram of Percent Correct of AOL Control Test Question Group

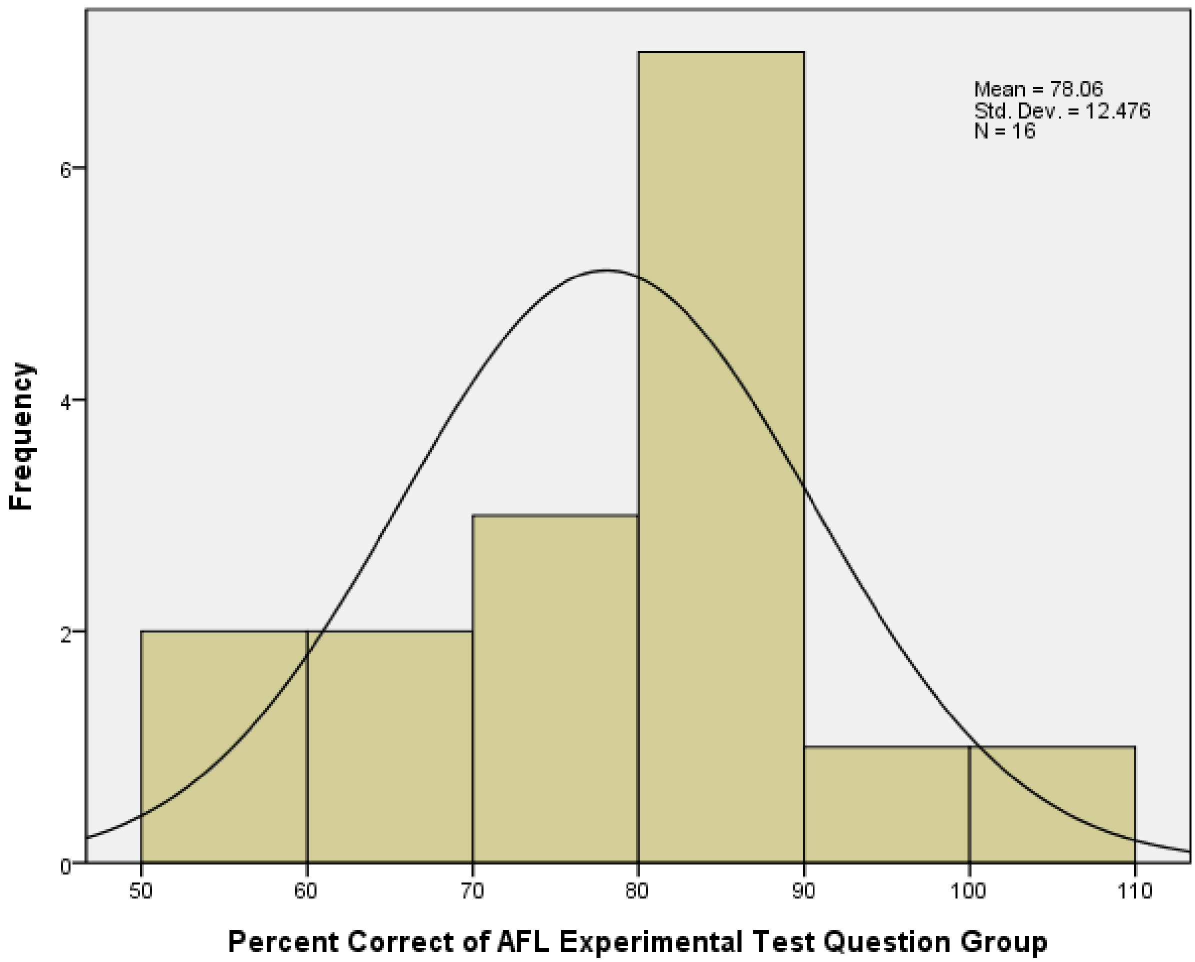


Figure 7.6 Histogram of Percent Correct of AFL Experimental Test Question Group

CHAPTER 8

SUMMARY OF TEST CASE

8.1 Summary

With the application of “assessment for learning” in this test case, new tools and supporting applications were instituted in the FSG course that energized student learning. Thus, the task of addressing s-g student needs was accomplished by working through the four objectives given below to implement the “assessment for learning” methodology. These objectives were applied in this test case study of the online FSG course and were considered to be the most impactful based on the complete course offering process.

The first objective was to design an assessment plan that incorporated assessments and supporting applications for the online FSG course that optimized the application of the concept of “assessment for learning.” The “assessment for learning” concept was chosen because it transforms assessment from being an after-the-fact student performance metric into a tool that can be used to increase student learning. As part of the assessment plan for the FSG course, it was important to address the desired ABET Student Learning Outcomes and the appropriate coverage of subjects in the NCEES standardized surveying exams. (FS & PS Exams) Thus, an assessment plan matrix was developed that mapped out the course in terms of subject coverage, assessments and the application of supporting methods. The resulting matrix organized and formatted to allow display on a single page or screen to facilitate viewing the assessment interactions for the entire course. (See Table 3.5.)

Within the assessment plan, the following assessment tools and supporting applications proved to be a driving force in the FSG student's course performance.

- **Pre-test:** Pre-tests were given for all 13 learning modules in the FSG course and supported self-evaluation by the student as well as providing feedback for test performance and guidance for student learning improvement. Even though the pre-tests were not a credited assessment, the successful completion of the pre-test was a condition for taking the subsequent module quiz. Thus, the pre-test was a vital part of the assessment plan and a number of students indicated that this was an important element.
- **Chat:** The online chat tool provided a high level of student-instructor interaction since responses to predetermined talking points and questions were shown to the entire class as written responses. The chat discussions also provided further self-evaluation for the FSG student and allowed the introduction of new concepts in concert with the student's existing knowledge of the subject. Chats were performed weekly and students were encouraged to complete the pre-test prior to the chat. Thus, like the pre-test, the chat session was found to be a very supportive part of the overall assessment plan.
- **Discussions:** The discussion tools provided in selected modules gave students viable examples of learning techniques which in turn helped to improve student learning in the FSG course. Discussions differed from the chat sessions since they were extended assignments where the student had more time to develop their responses for the discussions. Responses to discussions were based on materials that were provided in the course and /or researched by the student. Discussions focused on the

students' ability to assimilate new learning methods over the module's time period while the chat sessions provided a more spontaneous interaction with the student.

- **Module Quizzes:** Having two module quizzes available for assessment allowed the student more opportunity for feedback and guidance. The dual quizzes actually encouraged additional material exposure and problem-solving practice when the student took the second quiz.
- **Performance Assessments:** The coverage of performance assessments included the preceding modules with their related assessments and supporting tools. Thus, the performance assessment allowed the FSG student another chance to improve their knowledge and skills in a progressive way prior to the course's summative assessment. Also, the performance assessments were authentic assessments which afforded the student exposure to real world problems and were considered valuable by many of the FSG students.

With the "assessment for learning" plan established, the assessments and supporting applications were optimized by maximizing the use of the standard tools provided in the FSG course platform. This use of standardized tools was emphasized because the development of specialized resources for the course was not practical due to extensive labor requirements and because the intent was to develop assessment improvements that could easily be adopted in other courses required in a typical s-g curriculum. With the FSG course restructured to accommodate the "Assessment for Learning" (AFL) optimization, implementation could be accomplished through the FSG course offerings for the Fall 2012, Spring 2013, Summer 2013 and Fall 2013 semesters at MGSC.

The next objective was the development of a data driven model to measure and validate student learning in the online FSG course. The model was developed using an analysis of common quiz question (CQQ) analysis and the Final Exam (control test) as a means to measure and evaluate changes in student as a result of the changes in the course structure. Model development was comprised of a number of individual steps including selection of the common questions (CQQ) to be used for analysis, incorporation of the selected questions into the course module quizzes and final exam, and collection and analysis of the results.

The CQQ selection process involved evaluating the performance of students on the eight Unit Tests used in the “AOL” course offerings. This performance analysis provided a ranking of groups based on the correct responses to the Unit Test questions. From this ranking, the final selection of the common questions was made and allowed for future performance analysis according to ranking groups. (See Table 4.2 for an example of the CQQ selection matrix.) The Final Exams (Control Test) from the “AOL” course offerings were also evaluated and found to be consistent with FSG-ABET course learning objectives and with NCEES FS-PS testing criteria.

The Common questions selected were applied in the thirteen Module Quizzes in the AFL control course offerings. Likewise, the Final Exam (Control Test) was applied at the end of the semester for the AFL course offerings. With the AFL course offerings completed, the student performance data from FSG course module quizzes (AFL) & Unit Quizzes (AOL) as well as the Final Exam (control test) (AFL & AOL) were extracted, processed and analyzed in order to measure and validate student learning based on the CQQ.

The third step was implementation of the AFL program and collection of the results of student performance to estimate the effectiveness of the AFL assessment plan by examining student academic performance for both the AOL and AFL versions of the FSG course. Student learning was measured by academic performance and in this study it was based on the analysis of the student performance on Common Quiz questions and the Final Exam (control test). The analysis of Common Questions and the Final Exam (Control Test) was performed as described below.

As discussed earlier in this report, seventy-three representative common questions were established as a metric for measuring student learning in the FSG course. In order to utilize these questions for analysis the following steps were performed:

- For the control course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2009, Summer 2010, Summer 2010, Fall 2010, Summer 2011, and Fall 2011 semesters.
- For the experimental course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2012, Spring 2013, Summer 2013 and Fall 2013 semesters.

For each question, the difference in % correct was determined by subtracting the AOL percent correct (control) from the AFL percent correct (experimental). (Thus, a +percent correct indicated an increase in percent correct for a particular question and a –percent represents the converse.) The extended analysis included:

- Grouping by number and difference in percent correct for the question base: It was found that the average increase in % correct of CQQ based on a comparison of the control group versus the experimental group (AFL-AOL) was +7.5%.
- Grouping by the difference in percentage correct by percentile: The Percentile Breakdown of the increase in % correct (AFL-AOL) of CQQ was given as follows:
    - Lower 25%: -1.3%
    - Middle 50%: +4.9%
    - Upper 75%: +17.1%

  This analysis indicates that the upper 75% of the positive CQQ is performing at a much stronger positive rate than the lower 25% which is performing in the negative range. Also, the Middle 50% is showing an average of 4.9% which well into the positive range.

- Grouping by the difference in percent correct by common question-AOL ranking: Utilizing the ranking analysis from the AOL question selection method, the results were:
    - Low Ranking CQQ – Twenty-Five CQQ with an increase in % correct of +15.3%,
    - Median Ranking CQQ – Thirty-Three CQQ with an increase in % correct of +6.5
    - High Ranking CQQ: Fifteen CQQ with an increase of % correct of -3.4% (decrease).

- The above results are significant in that they show that the average of the median and low ranking groups' % correct increases were much greater than the negative increase (decrease) of question % correct results reflected in the high ranking group. Also, it shows that the performance reflected in the high ranking group warrants future investigation.
- Grouping by the difference in percent correct by subject grouping averages: Based on a breakdown of the CQQ by Subject Area Groups which included a division of 38 subject areas, the high and low performance subject area groups were identified as follows:

    - Highest % increase (average) – Subject Area: Leveling - Field Operation and Care Group: <u>+37.8%</u>

    - Lowest % increase (average) – Subject Area: Problems applied to Errors in Surveying Group: <u>-12.2%</u>

  Both of these subject areas are important for future study to see if any specific cause for these differing results can be tied to the experimental treatment. A further breakdown by subject areas based on a positive or negative % correct increase gave the following results:

    - Subject Area Groups with + % correct increase: <u>28 Groups or (73.7%)</u>

    - Subject Area Groups with a - % correct increase (decrease): <u>10 Groups or 26.3%</u>

- Grouping by the difference in percent correct for high and low performing question groups: The ten highest and the ten lowest performing CQQs in terms of % correct increase were grouped and selected for review. The average + % increase for the highest performing group was <u>+30.1%</u> while the average for the lowest performing group was <u>-11.4%</u>. The lowest performing group had only high (40%) and median (60%) ranked questions based on the AOL selection analysis. The highest performing group had only low (80%) and median (20%) ranked questions. This analysis indicates the need for future investigation into the possible cause for the improvement of the performance on the lower ranked questions and into the possible cause for the lack of improvement in the high and median questions.

As discussed earlier for the Final Exam, twenty-three representative questions were established as a metric for measuring summative student learning in the FSG course. In order to use these questions for analysis the following steps were performed:

  - For the control course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2009, Summer 2010, Summer 2010, Fall 2010, Summer 2011, and Fall 2011 semesters.

  - For the experimental course offerings, question performance (number & percentage of correct answers) was calculated and aggregated for Fall 2012, Spring 2013, Summer 2013 and Fall2013 semesters.

For each student, the twenty-three representative questions were validated for the correct response and the percentage correct was determined. The percentage correct was averaged for both the AOL (control) and the AFL (experimental) groups. The difference in percent correct +12.61% (78.06% – 65.45%) was determined by subtracting the AOL percent correct average (control) from the AFL percentage correct average (experimental).

A final objective of the case study was to provide the framework for a method based on pre-course student data and academic performance indicators to characterize online surveying-geomatics students and to predict the future performance of the students in the FSG course. For the student characterization data, the Middle Georgia College and the MGSC Banner© Databases were utilized and the process included the following steps:

- A thorough examination of the MGSC student forms and the entry fields in Banner© program required for application to the college was performed to verify overall data integrity.
- A listing of desired data was developed including: admissions data, Banner matriculation data, student curriculum information data, student standardized test score data, degrees awarded data, total hours transferred data, specific course transfer data and specific course-MGC credit data.
- The variables identified for student characterization after data cleaning included Student Age, High School Grade Point Average, Student Sex, SURV 1500/MATH 1112 Grades, SURV 2501 Grades, Institution Cumulative Credit Hours, and Institution Grade Point Average.
- The student characterization variables were grouped for three time periods based on first semester of attendance as follows:
    - Introductory Group: Spring 2003-Summer 2009
    - Control Group: Fall 2009-Fall 2011

- Experimental Group: Fall 2012-Fall 2013

- Finally, the majority of the variables were analyzed by performing descriptive statistics.

Extending the analysis, after careful consideration of the available student characterization variables, a framework for predicting student FSG course performance was proposed as given in appendix "D" of this study.

8.2 Conclusions from Test Case

An assessment plan for the online FSG course was developed that optimized the application of the concept of "assessment for learning." This application included the following:

- Using online course platform tools, a viable assessment plan can be created that optimizes "Assessment for Learning" in the FSG course.
- This assessment plan can be done in a manner that supports ABET Student Learning Outcomes and appropriate coverage of subjects in the NCEES standardized surveying exams. (FS & PS Exams)
- This assessment plan and supporting applications as applied in this research allowed students to show positive increases in student learning for the majority of subjects covered in the FSG course. These increases are highlighted as follows:
    - Overall increase in average CQQ performance in module quizzes (Experimental Group – Control Group), <u>+7.5 %</u>.
    - Overall increase in average unit test/ module quiz scores (Experimental Group – Control Group), <u>+ 8.6 points</u>.

- Overall increase in average Final Exam Common Questions performance (Experimental Group – Control Group), <u>+12.6 %</u>.
- Overall increase in average CQQ performance in module quizzes (Experimental Group – Control Group), <u>+7.5 %</u>.
- Overall increase in average Final Exam scores (Experimental Group – Control Group), <u>+8.4 points</u>.
- Overall increase in average Numeric Final Grade (Experimental Group – Control Group), <u>+5.8 points</u>.

- Utilizing a matrix for the assessment plan allowed the required content headers and the assessment tools and supporting applications to be seen in a one sheet document.

A data driven model to measure and validate student learning in the online FSG course was developed as follows:

- This model for measuring and validating student learning utilized common question analysis and Final Exam (Control test) analysis.
- Data from the unit quizzes (AOL) was extracted, processed and analyzed in order to produce a common questions selection methodology that was consistent with the desired subject coverage and allowed for extended analysis of the impact of “Assessment for Learning “on student learning in the FSG course.

The student performance data from FSG course module quizzes (AFL) and Unit Quizzes (AOL) in the form of CQ was extracted processed and analyzed in order to measure and validate student learning.

- The student performance data from FSG course Final Exam (control test) (AFL & AOL) was extracted, processed and analyzed in order to measure and validate student learning.

An experimental (quasi-experimental) design that utilizes data from FSG course offerings was developed to estimate the effectiveness of the proposed “assessment for learning” assessment plan. This process resulted in the following:

- Taking results from the data driven model, a design that examines the increases in student learning resulting from “AFL” was developed.
- The common questions as selected allowed an examination of the student performance on individual questions and question groups.
- Subject areas with greater improvement of student learning were shown. Also, areas of weaker performance could be identified for additional actions in future course offerings.
- The increase in % correct of common questions (+7.5%) combined with the increase in % correct of questions in the Final Exam (control test) (+12.6%) when applied the current FSG course grading scheme yields a potential increase in course grade of 6.0 points. Thus, illustrating the potential impact of the “Assessment for Learning” concept.

The framework for a method based on pre-course student data and academic performance indicators to characterize online surveying-geomatics students was developed through the examination and statistical analysis of pre-course student data and academic performance indicators.

In summary, though based on limited data and course timing constraints, the majority of metrics developed to measure student learning indicate that the application of “assessment for learning” has resulted in an improvement in student learning when compared to applications of “assessment of learning” in the online FSG course. As such, the continued application of “assessment for learning” in the online FSG course and other online s-g courses should be pursued.

8.3 Future Research

The following subjects were identified during this research and merit serious future study in order to help the surveying profession survive and to help meet the educational needs of the next generation of Civil Engineering and Surveying-Geomatics students:

- In terms of s-g student performance prediction, an examination of the most effective admissions/application data to be obtained from new s-g students should be performed.
- In the FSG course, an examination of the relationships between smaller predictive CQQ groups and the student learning should be performed.
- A study that utilizes a geospatial analysis platform should be performed to examine the impact of pre-course socio-economic factors on s-g student characterization and performance prediction.
- A study should be performed that examines the relationship between student affective responses and actual student learning in the online FSG course.
- With increased student numbers and increased applications of “assessment for learning”, a study should be performed that examines the relative effectiveness of each of the assessment tools and supporting applications in the FSG course assessment plan.

CHAPTER 9

CONCLUSIONS

9.1 Summary

Based on current trends, the s-g profession is facing significant challenges for the foreseeable future. Several factors indicate that the profession may be in a broad, but hopefully not irreversible, decline. There are fewer students interested in s-g careers and this has led to both a decline in enrollments in s-g programs and fewer new s-g professionals being licensed. When coupled with the retirement of increasing numbers of existing s-g professionals, these trends should, and do, elicit extreme concern for our national ability to maintain a viable s-g professional infrastructure into the future. This current situation begs the question: How are we as a profession going to solve these problems and bolster an s-g profession that meets the construction, land measurement and geospatial data needs of the 21st century?

Embedded in the troubles of the s-g profession at large are the additional concerns and constraints that are stressing s-g educational programs to the breaking point. The resources of these s-g educational institutions in terms of budgets, available instructors and time have been severely constrained just as the technology content in s-g measurement has exploded. As one way to deal with these constraints, higher education institutions have looked to online education to provide a new platform that reaches out to place-bound students who might otherwise not be able to get the necessary education to become an s-g professional. These place-bound students are already contributing significantly to the overall s-g profession numbers and represent the most likely pool of available students with which to expand s-g education in the future.

Looking more closely at this source of new s-g students and their needs, it has become apparent that online courses for the 21st Century must go beyond merely mimicking traditional classroom instruction and serving as a repository for s-g educational materials as many of the current online courses provide. The online s-g courses for the 21st Century must meet the unique needs of place-bound students by providing new tools and techniques that give these students the type of continuous feedback and guidance in their educational activities that promote both success and user satisfaction. Traditional assessment methods (e.g. those discussed previously as ”Assessment of Learning”) simply do not provide the kind of timely feedback to either the student or instructor that allows either or both of these parties to take immediate corrective actions that can improve learning outcomes.

Thus to effectively educate these place-bound students are as future s-g professionals, we must develop, or re-develop courses, curricula and assessment methods to maximize learning and to engage and excite these students as to the prospect of an s-g career. In doing so, these s-g courses must provide a nurturing learning environment to educate these students in fundamental and advanced concepts; the use of traditional and new technologies as well as providing them with the other technical, legal, and communications skills required for licensure as an s-g professional. Yet, these courses must be developed within the time constraints, limited budgets and instructor shortages that currently challenge s-g educational institutions. It is therefore essential to ensure that the basic framework employed to develop these courses is sound as it is unlikely that resources will be available to replace them should they prove to be ineffective.

In this study, we have explored the problems associated with making the introductory Fundamentals of Surveying and Geomatics (FSG) course ready for the 21^{st} Century and have proposed a framework based on the "Assessment for Learning" approach that we believe will provide a strong basis for formulating complete curricula. Specifically we have:

- Developed a method of evaluating the effectiveness of course improvements via assessment methods.
- Developed an alternative course delivery system in an effort to improve student learning and engagement via the implementation of "assessment for learning".
- Implemented a test case that includes the new tools and methods cited above.
- Evaluated the effectiveness of the changes to the FSG course via measurements of academic performance on the student learning metrics developed for the course.

The results of this study indicate that student learning can be improved in the FSG course through the application of an assessment plan that focuses on "assessment for learning" and that includes course design and delivery tools that best match the student needs. Further, this study has shown that FSG students can be characterized by key variables in order to improve the understanding of the relationship between pre-course student data & pre-course academic performance metrics and the predicted student performance in the FSG course. This research was intended for civil engineering and surveying-geomatics educators and as such has provided knowledge of the impact of a viable assessment plan. In addition, it is hoped that these educators will find the methodology usable, illustrative and applicable to their coursework.

While this study looks at just one course in the s-g education curriculum, there are many other challenges that face the s-g profession in the 21st Century. These challenges are identified in terms of the stakeholder groups as given below:

- For the overall group of s-g stakeholders including the national s-g societies, the state s-g societies, the state boards for regulation of s-g, the s-g practitioners, the s-g educators and the s-g students, the following challenges must be met directly:
    - The overall s-g group must attract more students who are potentially successful. This challenge means that:
        - a better way to articulate the definition and value of the s-g profession in general must be developed,
        - the economic impact of the s-g profession must be evaluated and conveyed to the potential s-g student,
        - the benefits of s-g licensure must be defined,
        - the possibilities of business entrepreneurship must be emphasized,
        - and better connections for the s-g student to internships & jobs of the 21^{st} century must be developed.
    - The overall s-g group must work collaboratively to encourage high quality s-g students to pursue graduate education, research and teaching.
    - The overall s-g group must work collaboratively to find ways to optimize the use of state and federal resources to assist the s-g profession in moving forward.

    - The overall group must find innovative ways to sustainably fund new s-g equipment and training for new s-g technology for both formal s-g education and continuing education for practitioners.

- In terms of national level impact, the national s-g organizations must continue to support state s-g societies and state regulatory boards by creating national goals for s-g improvements in education, student promotion and resources.
- In terms of state impact, stakeholders must continue to support the protection of the public as impacted by the s-g profession. These stakeholders must work together to ensure that the applicable laws, rules and interpretations are sustainable and that they support developing & new s-g technology in terms of the knowledge and skill required for licensure and for continuing education. Also, these stakeholders must work together and set goals for the improvement of the s-g profession.
- S-G practitioners, instructors and students need to collaborate to produce course, labs and internships for the 21st century that are sustainable and that ensure that the student is successful on licensure exams and that the student is ready to assume the role of a professional at the appropriate time.
- Educators need to maintain a current knowledge of s-g technology developments and as well as teaching advances for all types of course platforms and presentations. Additionally, educators should apply this new information into their s-g courses in a manner that supports measurable student learning or improvements in student learning.

9.2 Future Research

From this study, the following subjects were identified and merit serious future study in order to help the surveying profession survive and to help meet the educational needs of the 21st century generation of Civil Engineering and Surveying-Geomatics students:

- Study the application of “assessment for learning” for other appropriate coursework in the s-g curriculum. This study should highlight the selection and application of “assessment for learning” & supporting applications as based on student needs. In the FSG course as more data becomes available, an examination of the relationships between smaller and more diverse predictive CQQ groups and the student learning should be performed.
- For the FSG course, a study that utilizes a geospatial analysis platform should be performed to examine the impact of pre-course socio-economic factors on s-g student characterization and performance prediction. The framework for this analysis should be applicable to appropriate courses in the s-g curriculum beyond the FSG course.
- A study should be performed that examines the relationship between student affective responses and actual student learning in the online FSG course.
- With increased student numbers and increased applications of “assessment for learning”, a study including a time series evaluation should be performed that examines the relative effectiveness of each of the assessment tools and supporting applications in the FSG course assessment plan.
- In terms of s-g student performance prediction, an examination of the most effective admissions/application data to be obtained from new s-g students should be performed.

- Examine the ways to optimize the inclusion of high quality s-g instructors' and eminent scholars' contributions into typical s-g coursework.
- With NCEES cooperation, complete a time–series study on the performance of s-g students on the FS/PS exams. This study should highlight the "application of assessment for learning".
- Examine the effectiveness of exam preparatory courses on the successful passing of FS/PS exams.
- Study innovative ways to provide effective lab experiences to place-bound s-g students which include the participation of local practitioners as lab instructors.
- Examine business strategies that allow s-g business practices to be sustainable. These strategies must include a method for the acquisition of emerging technology and associated equipment & training.

APPENDIX A

ABET AND NCEES CRITERIA FOR SURVEYING-GEOMATICS

CRITERIA FOR ACCREDITING APPLIED SCIENCE PROGRAMS

Effective for Reviews During the
2013-2014 Accreditation Cycle

Incorporates all changes
approved by the
ABET
Board of Directors
as of
October 27, 2012

PROGRAM CRITERIA FOR
SURVEYING, GEOMATICS
AND SIMILARLY NAMED APPLIED SCIENCE PROGRAMS
Lead Society: American Congress on Surveying & Mapping
Cooperating Society: American Society of Civil Engineers

These program criteria apply to surveying, surveying and mapping, geomatics, and similarly-named applied science programs.

I. PROGRAM CRITERIA FOR BACCALAUREATE LEVEL PROGRAMS

A. Curriculum

Programs at the baccalaureate level must demonstrate that graduates have proficiency in one or more of the following areas: boundary and/or land surveying, geographic and/or land information systems, photogrammetry, mapping and geodesy, remote sensing, and other related areas.

B. Faculty Qualifications

The program faculty must have responsibility and sufficient authority to define, revise, implement, and achieve program objectives. The program must demonstrate that faculty members are qualified to teach the subject matter by virtue of professional licensure or by education and/or professional experience.

II. PROGRAM CRITERIA FOR ASSOCIATE LEVEL PROGRAMS

A. Curriculum

Programs at the associate level must demonstrate that graduates have competency in one or more of the following areas: boundary and/or land surveying, geographic and/or land information systems, photogrammetry, mapping and geodesy, remote sensing, and other related areas.

B. Faculty Qualifications

The program faculty must have responsibility and sufficient authority to define, revise, implement, and achieve program objectives. The program must demonstrate that faculty members are qualified to teach the subject matter by virtue of professional licensure or by education and/or professional experience.

NCEES FUNDAMENTALS OF SURVEYING (FS) EXAM SPECIFICATIONS

Surveying Reference Formulas

October 11, 2010

The morning and afternoon FS exam books will include reference material similar to the material shown here. Basic theories, conversions, formulas, and definitions that examinees are expected to know have not been included. When appropriate, NCEES will provide special material in the question statement itself to assist you in solving the problem.

CONVERSIONS AND OTHER USEFUL RELATIONSHIPS

* 1 U.S. survey foot = $\dfrac{12}{39.37}$ m
* 1 international foot = 0.3048 m
* 1 in. = 25.4 mm (international)
  1 mile = 1.60935 km
* 1 acre = 43,560 ft^2 = 10 square chains
* 1 ha = 10,000 m^2 = 2.47104 acres
* 1 rad = $\dfrac{180^\circ}{\pi}$

1 kg = 2.2046 lb
1 L = 0.2624 gal
1 ft^3 = 7.481 gal
1 gal of water weighs 8.34 lb
1 ft^3 of water weighs 62.4 lb
1 atm = 29.92 in. Hg = 14.696 psi
Gravity acceleration (g) = 9.807 m/s^2 = 32.174 ft/sec^2
Speed of light in a vacuum (c) = 299,792,458 m/s = 186,282 miles/sec
°C = (°F – 32)/1.8
1 min of latitude (ϕ) ≅ 1 nautical mile
1 nautical mile = 6,076 ft
Mean radius of the earth ≅ 20,906,000 ft ≅ 6,372,000 m

* Denotes exact value. All others correct to figures shown.

METRIC PREFIXES		
Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	**micro**	**μ**
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d

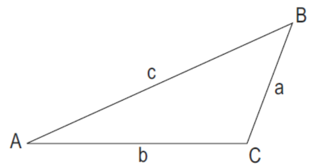
METRIC PREFIXES		
Multiple	Prefix	Symbol
10^{1}	deka	da
10^{2}	**hecto**	**h**
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	**peta**	**P**
10^{18}	exa	E

QUADRATIC EQUATION

$ax^2 + bx + c = 0$

$$\text{Roots} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

OBLIQUE TRIANGLES



Law of sines

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Law of cosines

$$a^2 = b^2 + c^2 - 2bc\cos A$$

or

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$$

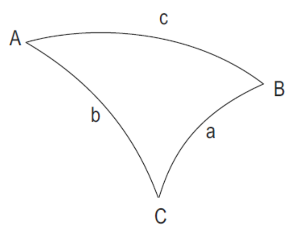
$$\text{Area} = \frac{ab\sin C}{2}$$

$$\text{Area} = \frac{a^2 \sin B \sin C}{2\sin A}$$

$$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$$

where $s = (a + b + c)/2$

SPHERICAL TRIANGLES



Law of sines

$$\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin C}$$

Law of cosines

$\cos a = \cos b \cos c + \sin b \sin c \cos A$

Area of sphere $= 4\pi R^2$

Volume of sphere $= \frac{4}{3}\pi R^3$

$$\text{Spherical excess in sec} = \frac{bc \sin A}{9.7 \times 10^{-6} R^2}$$

where R = mean radius of the earth

PROBABILITY AND STATISTICS

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{\sum v^2}{n-1}}$$

where:

- σ = standard deviation (sometimes referred to as standard error)
- $\sum v^2$ = sum of the squares of the residuals (deviation from the mean)
- n = number of observations
- $\bar{x}$ = mean of the observations (individual measurements x_i)

$$\sigma_{sum} = \sqrt{\sigma_1^2 + \sigma_2^2 + \ldots + \sigma_n^2}$$

$$\sigma_{series} = \sigma\sqrt{n}$$

$$\sigma_{mean} = \frac{\sigma}{\sqrt{n}}$$

$$\sigma_{product} = \sqrt{A^2\sigma_b^2 + B^2\sigma_a^2}$$

$$\Sigma = \begin{bmatrix} \sigma_x^2 & \sigma_{xy} \\ \sigma_{xy} & \sigma_y^2 \end{bmatrix}$$

$$\tan 2\theta = \frac{2\sigma_{xy}}{\sigma_x^2 - \sigma_y^2}$$

where θ = the counterclockwise angle from the x axis

Relative weights are inversely proportional to variances, or:

$$W_a \propto \frac{1}{\sigma_a^2}$$

Weighted mean:

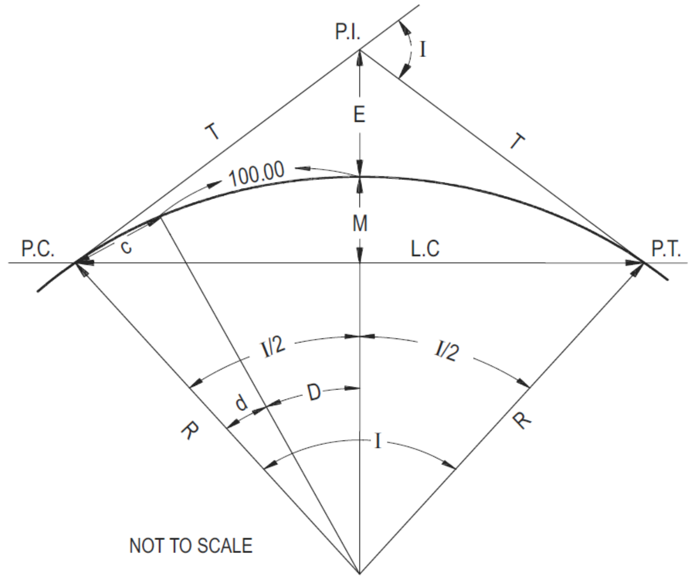
$$\bar{M}_W = \frac{\sum WM}{\sum W}$$

where:

- $\bar{M}_W$ = weighted mean
- $\sum WM$ = sum of individual weights times their measurements
- $\sum W$ = sum of the weights

HORIZONTAL CIRCULAR CURVES

D = Degree of curve, arc definition
L = Length of curve from P.C. to P.T.
c = Length of sub-chord
ℓ = Length of arc for sub-chord
d = Central angle for sub-chord



$$D = \frac{5{,}729.58}{R}$$

$$T = R \tan(I/2)$$

$$L = RI\frac{\pi}{180} = \frac{I}{D}(100)$$

$$LC = 2R \sin(I/2)$$

$$c = 2R \sin(d/2)$$

$$d = \ell D/100$$

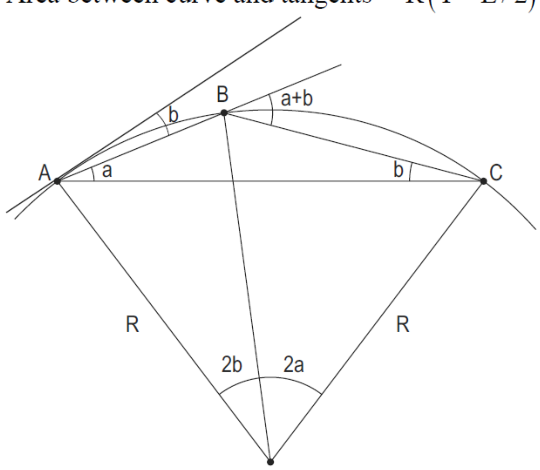
$$M = R\left[1 - \cos(I/2)\right]$$

$$E = R\left[\frac{1}{\cos(I/2)} - 1\right]$$

$$\text{Area of sector} = \frac{RL}{2} = \frac{\pi R^2 I}{360}$$

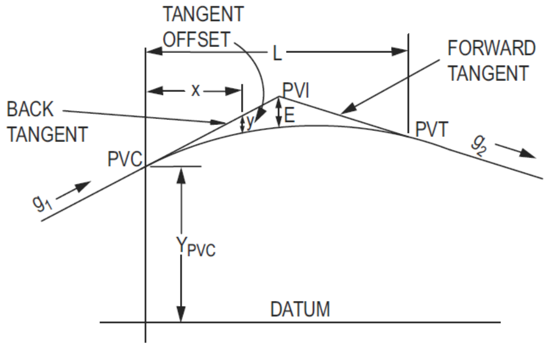
$$\text{Area of segment} = \frac{\pi R^2 I}{360} - \frac{R^2 \sin I}{2}$$

$$\text{Area between curve and tangents} = R(T - L/2)$$



$$R = \frac{AC}{2 \sin(a+b)}$$

VERTICAL CURVE FORMULAS



VERTICAL CURVE FORMULAS
NOT TO SCALE

L = Length of curve (horizontal)
PVC = Point of vertical curvature
PVI = Point of vertical intersection
PVT = Point of vertical tangency
g_1 = Grade of back tangent
g_2 = Grade of forward tangent
x = Horizontal distance from PVC (or point of tangency) to point on curve
a = Parabola constant
y = Tangent offset
E = Tangent offset at PVI
r = Rate of change of grade

Tangent elevation = $Y_{PVC} + g_1 x$
and = $Y_{PVI} + g_2 (x - L/2)$

Curve elevation $= Y_{PVC} + g_1 x + ax^2$
$= Y_{PVC} + g_1 x + [(g_2 - g_1)/(2L)]x^2$

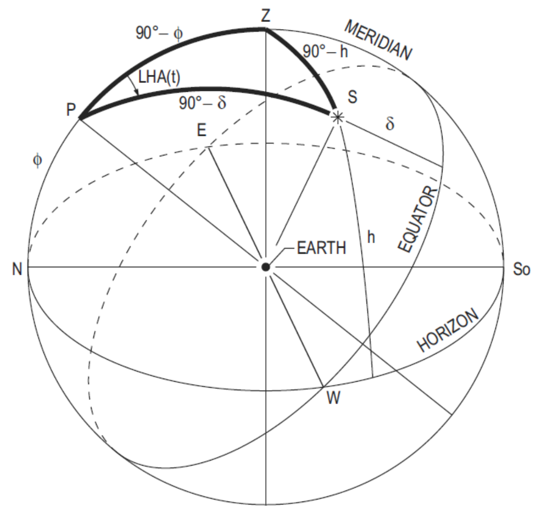
$$y = ax^2; \qquad a = \frac{g_2 - g_1}{2L};$$

$$E = a\left(\frac{L}{2}\right)^2; \qquad r = \frac{g_2 - g_1}{L}$$

Horizontal distance to min/max elevation on curve,

$$x_m = -\frac{g_1}{2a} = \frac{g_1 L}{g_1 - g_2}$$

ASTRONOMY



$\text{Cos (Az)} = (\sin\delta - \sin\phi \sin h) / (\cos\phi \cos h)$
(altitude method)

$\text{Tan (Az)} = -\sin(\text{LHA}) / (\cos\phi \tan\delta - \sin\phi \cos(\text{LHA}))$
(hour angle method)

$\text{Sin h} = \sin\phi \sin\delta + \cos\phi \cos\delta \cos \text{LHA}$

$t = \text{LHA or } 360° - \text{LHA}$

Horizontal circle correction for sun's semi-diameter = SD/cos h

Equations accurate for Polaris only:

$h = \phi + p \cos \text{LHA}$
$Az = -(p \sin \text{LHA})/\cos h$

where:

Az = Azimuth (from north) to sun/star
δ = Declination
ϕ = Latitude
h = Altitude of sun/star
LHA = Local hour angle (sometimes referred to as "t" or "hour angle")
SD = Arc length of sun's semi-diameter
p = Polar distance of Polaris

PHOTOGRAMMETRY

$$\text{Scale} = \frac{ab}{AB} = \frac{f}{H-h} \qquad \text{(vertical photograph)}$$

$$\text{Relief displacement} = \frac{rh}{H} \qquad \text{(vertical photograph)}$$

Parallax equations:

$$p = x - x'$$

$$X = \frac{xB}{p}$$

$$Y = \frac{yB}{p}$$

$$h = H - \frac{fB}{p}$$

$$h_2 = h_1 + \frac{(p_2 - p_1)}{p_2}(H - h_1)$$

where:

- f = Focal length
- h = Height above datum
- H = Flying height above datum
- r = Radial distance from principal point
- p = Parallax measured on stereo pair
- B = Airbase of stereo pair
- x, y = Coordinates measured on left photo
- x' = Coordinate measured on right photo
- X, Y = Ground coordinates

PHYSICS

Lens equation:

$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$$

where:

- o = Object distance
- i = Image distance
- f = Focal length

Snell laws:

$$n \sin \phi = n' \sin \phi'$$

where:

- n = Refractive index
- ϕ = Angle of incidence

Curvature and refraction:

$$(c + r) = 0.0206M^2$$

where:

- $(c + r)$ = Combined effect of curvature and refraction in feet
- M = Distance in thousands of feet

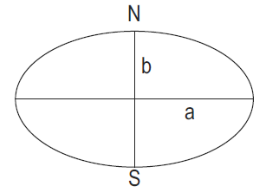
$$s = \frac{1}{2}at^2$$

where:

- s = Distance traveled starting from zero velocity
- a = Constant acceleration
- t = Time of travel

GEODESY

Ellipsoid



a = semimajor axis
b = semiminor axis

$$\text{Flattening, } f = \frac{a-b}{a} \qquad \text{(usually published as } 1/f\text{)}$$

$$\text{Eccentricity, } e^2 = \frac{a^2 - b^2}{a^2}$$

$$\text{Radius in meridian, } M = \frac{a\left(1-e^2\right)}{\left(1-e^2 \sin \phi\right)^{3/2}}$$

$$\text{Radius in prime vertical, } N = \frac{a}{\left(1-e^2 \sin^2 \phi\right)^{1/2}}$$

Angular convergence of meridians

$$\theta_{rad} = \frac{d \tan \phi \left(1 - e^2 \sin^2 \phi\right)^{1/2}}{a}$$

Linear convergence of meridians

$$= \frac{\ell d \tan \left(1 - e^2 \sin^2 \phi\right)^{1/2}}{a}$$

where:

- ϕ = Latitude
- d = Distance along parallel at latitude ϕ
- ℓ = Length along meridians separated by d

Ellipsoid definitions:

GRS80:	a	= 6,378,137.0 m
	$1/f$	= 298.25722101
Clark 1866:	a	= 6,378,206.4 m
	$1/f$	= 294.97869821

Orthometric correction:

$$\text{Correction} = -0.005288 \sin 2\phi h \Delta\phi \,\text{arc}\, 1'$$

where:

- ϕ = latitude at starting point
- h = datum elevation in meters or feet at starting point
- $\Delta\phi$ = change in latitude in minutes between the two points (+ in the direction of increasing latitude or towards the pole)

STATE PLANE COORDINATES

Scale factor = Grid distance/geodetic (ellipsoidal) distance

Elevation factor = R/(R + H +N)

where:

- R = Ellipsoid radius
- H = Orthometric height
- N = Geoid height

For precision less than 1/200,000:

- R = 20,906,000 ft
- H = Elevation above sea level
- N = 0

ELECTRONIC DISTANCE MEASUREMENT

$V = c/n$

$\lambda = V/f$

$$D = \left(\frac{m\lambda + d}{2}\right)$$

where:

- V = Velocity of light through the atmosphere (m/s)
- c = Velocity of light in a vacuum
- n = Index of refraction
- λ = Wave length (m)
- f = Modulated frequency in hertz (cycles/sec)
- D = Distance measured
- m = Integer number of full wavelengths
- d = Fractional part of the wavelength

ATMOSPHERIC CORRECTION

A 10°C temperature change or a pressure difference of 1 in. of mercury produces a distance correction of approximately 10 parts per million (ppm).

AREA FORMULAS

Area by coordinates where i is point order in a closed polygon.

$$\text{Area} = \frac{1}{2}\left[\sum_{i=1}^{n} X_i Y_{i+1} - \sum_{i=1}^{n} X_i Y_{i-1}\right]$$

Trapezoidal Rule

$$\text{Area} = w\left(\frac{h_1 + h_n}{2} + h_2 + h_3 + h_4 + \ldots + h_{n-1}\right)$$

Simpson's 1/3 Rule

$$\text{Area} = w\left[h_1 + 2\left(\sum h_{odds}\right) + 4\left(\sum h_{evens}\right) + h_n\right]/3$$

EARTHWORK FORMULAS

Average end area formula

Volume = $L(A_1 + A_2)/2$

Prismoidal formula

Volume = $L(A_1 + 4A_m + A_2)/6$

Pyramid or cone

Volume = h(Area of Base)/3

TAPE CORRECTION FORMULAS

Correction for temperature

$C_t = 6.5 \times 10^{-6} (T - T_s)L$

Correction for tension

$C_p = (P - P_s)L/(AE)$

Correction for sag

$C_s = (w^2 \ell^3) / (24P^2)$

where:

- T = Temperature of tape during measurement, °F
- T_s = Temperature of tape during calibration, °F
- L = Distance measured, ft
- P = Pull applied during measurement, lb
- P_s = Pull applied during calibration, lb
- A = Cross-sectional area of tape, in^2
- E = Modulus of elasticity of tape, psi
- w = Weight of tape, lb/ft
- ℓ = Length of unsupported span, ft

STADIA

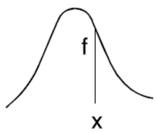
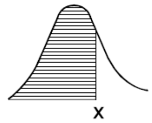
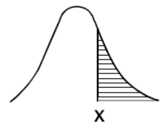
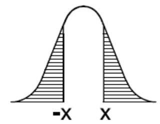
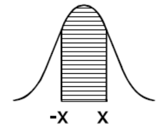
Horizontal distance = $KS \cos^2 \alpha$

Vertical distance = $KS \sin \alpha \cos \alpha$

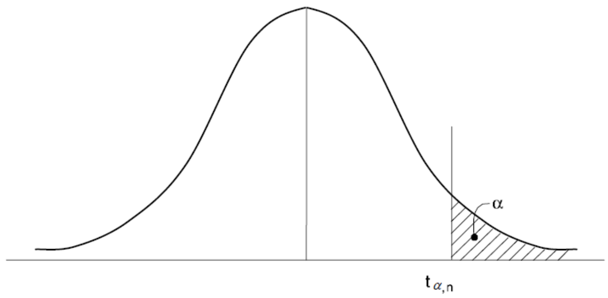
where:

- K = Stadia interval factor (usually 100)
- S = Rod intercept
- α = Slope angle measured from horizontal

UNIT NORMAL DISTRIBUTION TABLE

					
x	**f(x)**	**F(x)**	**R(x)**	**2R(x)**	**W(x)**
0.0	0.3989	0.5000	0.5000	1.0000	0.0000
0.1	0.3970	0.5398	0.4602	0.9203	0.0797
0.2	0.3910	0.5793	0.4207	0.8415	0.1585
0.3	0.3814	0.6179	0.3821	0.7642	0.2358
0.4	0.3683	0.6554	0.3446	0.6892	0.3108
0.5	0.3521	0.6915	0.3085	0.6171	0.3829
0.6	0.3332	0.7257	0.2743	0.5485	0.4515
0.7	0.3123	0.7580	0.2420	0.4839	0.5161
0.8	0.2897	0.7881	0.2119	0.4237	0.5763
0.9	0.2661	0.8159	0.1841	0.3681	0.6319
1.0	0.2420	0.8413	0.1587	0.3173	0.6827
1.1	0.2179	0.8643	0.1357	0.2713	0.7287
1.2	0.1942	0.8849	0.1151	0.2301	0.7699
1.3	0.1714	0.9032	0.0968	0.1936	0.8064
1.4	0.1497	0.9192	0.0808	0.1615	0.8385
1.5	0.1295	0.9332	0.0668	0.1336	0.8664
1.6	0.1109	0.9452	0.0548	0.1096	0.8904
1.7	0.0940	0.9554	0.0446	0.0891	0.9109
1.8	0.0790	0.9641	0.0359	0.0719	0.9281
1.9	0.0656	0.9713	0.0287	0.0574	0.9426
2.0	0.0540	0.9772	0.0228	0.0455	0.9545
2.1	0.0440	0.9821	0.0179	0.0357	0.9643
2.2	0.0355	0.9861	0.0139	0.0278	0.9722
2.3	0.0283	0.9893	0.0107	0.0214	0.9786
2.4	0.0224	0.9918	0.0082	0.0164	0.9836
2.5	0.0175	0.9938	0.0062	0.0124	0.9876
2.6	0.0136	0.9953	0.0047	0.0093	0.9907
2.7	0.0104	0.9965	0.0035	0.0069	0.9931
2.8	0.0079	0.9974	0.0026	0.0051	0.9949
2.9	0.0060	0.9981	0.0019	0.0037	0.9963
3.0	0.0044	0.9987	0.0013	0.0027	0.9973
Fractiles					
1.2816	0.1755	0.9000	0.1000	0.2000	0.8000
1.6449	0.1031	0.9500	0.0500	0.1000	0.9000
1.9600	0.0584	0.9750	0.0250	0.0500	0.9500
2.0537	0.0484	0.9800	0.0200	0.0400	0.9600
2.3263	0.0267	0.9900	0.0100	0.0200	0.9800
2.5758	0.0145	0.9950	0.0050	0.0100	0.9900

t-DISTRIBUTION TABLE

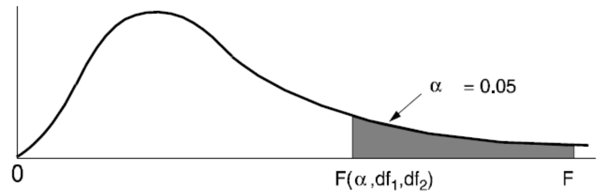


VALUES OF $t_{\alpha,n}$

n	$\alpha = 0.10$	$\alpha = 0.05$	$\alpha = 0.025$	$\alpha = 0.01$	$\alpha = 0.005$	n
1	3.078	6.314	12.706	31.821	63.657	1
2	1.886	2.920	4.303	6.965	9.925	2
3	1.638	2.353	3.182	4.541	5.841	3
4	1.533	2.132	2.776	3.747	4.604	4
5	1.476	2.015	2.571	3.365	4.032	5
6	1.440	1.943	2.447	3.143	3.707	6
7	1.415	1.895	2.365	2.998	3.499	7
8	1.397	1.860	2.306	2.896	3.355	8
9	1.383	1.833	2.262	2.821	3.250	9
10	1.372	1.812	2.228	2.764	3.169	10
11	1.363	1.796	2.201	2.718	3.106	11
12	1.356	1.782	2.179	2.681	3.055	12
13	1.350	1.771	2.160	2.650	3.012	13
14	1.345	1.761	2.145	2.624	2.977	14
15	1.341	1.753	2.131	2.602	2.947	15
16	1.337	1.746	2.120	2.583	2.921	16
17	1.333	1.740	2.110	2.567	2.898	17
18	1.330	1.734	2.101	2.552	2.878	18
19	1.328	1.729	2.093	2.539	2.861	19
20	1.325	1.725	2.086	2.528	2.845	20
21	1.323	1.721	2.080	2.518	2.831	21
22	1.321	1.717	2.074	2.508	2.819	22
23	1.319	1.714	2.069	2.500	2.807	23
24	1.318	1.711	2.064	2.492	2.797	24
25	1.316	1.708	2.060	2.485	2.787	25
26	1.315	1.706	2.056	2.479	2.779	26
27	1.314	1.703	2.052	2.473	2.771	27
28	1.313	1.701	2.048	2.467	2.763	28
29	1.311	1.699	2.045	2.462	2.756	29
∞	1.282	1.645	1.960	2.326	2.576	∞

CRITICAL VALUES OF THE F DISTRIBUTION – TABLE

For a particular combination of numerator and denominator degrees of freedom, entry represents the critical values of F corresponding to a specified upper tail area (α).



Denominator df_2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0	249.1	250.1	251.1	252.2	253.3	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Numerator df_1 spans columns 1 through ∞.

ECONOMICS

Factor Name	Converts	Symbol	Formula
Single Payment Compound Amount	to F given P	$(F/P, i\%, n)$	$(1+i)^n$
Single Payment Present Worth	to P given F	$(P/F, i\%, n)$	$(1+i)^{-n}$
Uniform Series Sinking Fund	to A given F	$(A/F, i\%, n)$	$\dfrac{i}{(1+i)^n-1}$
Capital Recovery	to A given P	$(A/P, i\%, n)$	$\dfrac{i(1+i)^n}{(1+i)^n-1}$
Uniform Series Compound Amount	to F given A	$(F/A, i\%, n)$	$\dfrac{(1+i)^n-1}{i}$
Uniform Series Present Worth	to P given A	$(P/A, i\%, n)$	$\dfrac{(1+i)^n-1}{i(1+i)^n}$
Uniform Gradient Present Worth	to P given G	$(P/G, i\%, n)$	$\dfrac{(1+i)^n-1}{i^2(1+i)^n}-\dfrac{n}{i(1+i)^n}$
Uniform Gradient † Future Worth	to F given G	$(F/G, i\%, n)$	$\dfrac{(1+i)^n-1}{i^2}-\dfrac{n}{i}$
Uniform Gradient Uniform Series	to A given G	$(A/G, i\%, n)$	$\dfrac{1}{i}-\dfrac{n}{(1+i)^n-1}$

Nomenclature and Definitions

A	Uniform amount per interest period
B	Benefit
BV	Book Value
C	Cost
d	Combined interest rate per interest period
D_j	Depreciation in year j
F	Future worth, value, or amount
f	General inflation rate per interest period
G	Uniform gradient amount per interest period
i	Interest rate per interest period
i_e	Annual effective interest rate
m	Number of compounding periods per year
n	Number of compounding periods; or the expected life of an asset
P	Present worth, value, or amount
r	Nominal annual interest rate
S_n	Expected salvage value in year n

Subscripts

j	at time j
n	at time n
†	$F/G = (F/A - n)/i = (F/A) \times (A/G)$

Nonannual Compounding

$$i_e = \left(1 + \frac{r}{m}\right)^m - 1$$

Book Value

BV = Initial cost – ΣD_j

Depreciation

Straight line $D_j = \dfrac{C - S_n}{n}$

Accelerated Cost Recovery System (ACRS)

D_j = (factor from table below) C

MODIFIED ACRS FACTORS				
Year	**Recovery Period (Years)**			
	3	**5**	**7**	**10**
	Recovery Rate (%)			
1	33.3	20.0	14.3	10.0
2	44.5	32.0	24.5	18.0
3	14.8	19.2	17.5	14.4
4	7.4	11.5	12.5	11.5
5		**11.5**	**8.9**	**9.2**
6		5.8	8.9	7.4
7			8.9	6.6
8			4.5	6.6
9				6.5
10				**6.5**
11				3.3

Capitalized Costs

Capitalized costs are present worth values using an assumed perpetual period of time.

Capitalized costs = $P = \dfrac{A}{i}$

NCEES PRINCIPLES AND PRACTICE OF SURVEYING (PS) EXAM SPECIFICATIONS

Effective Beginning with the October 2005 Examinations

- The exam is a 6-hour open-book exam. It contains 67 multiple-choice questions in the 4-hour morning session, and 33 multiple-choice questions in the 2-hour afternoon session. Examinee works all questions.
- The exam uses the US Customary System (USCS) of units.

Knowledge	Approximate Percentage of the Examination
I. Standards and Specifications	**15%**
A. Federal statutes, laws, rules and regulations	
B. U.S. Public Land Survey System	
C. U.S. National Map Accuracy Standards	
D. ALTA/ACSM Surveys	
E. Geodetic control network and mapping accuracy standards	
F. FEMA	
II. Legal Principles	**25%**
A. Common/case law boundary principles	
B. Sequential and simultaneous conveyances	
C. U.S. Public Land Survey System	
D. Controlling elements in legal descriptions	
E. Riparian and littoral rights	
F. Property title issues (e.g., encumbrances, interpretation, deficiencies)	
G. Sovereign land rights (e.g., navigable waters, eminent domain)	
H. Prescriptive rights/adverse possession	
I. Easement rights	
J. Parol evidence	
III. Professional Survey Practices	**30%**
A. Research	8%
1. Public/private record sources	
2. Project planning (e.g., photogrammetric, geodetic, boundary)	
3. Control datums and easement rights	
4. Control network accuracy standards	
B. Field Procedures	8%
1. Instrument operations and usage	
2. Monumentation (e.g., identification, classification, perpetuation)	
3. Survey control (e.g., boundary, topographic, photogrammetric)	
4. GPS operations	

5. Construction staking

C. Calculations and Compilations 7%

1. Mapping methods and/or projections
2. Graphical terrain representations
3. Geoid, ellipsoid, and orthometric heights
4. State Plane Coordinate Systems
5. GPS data reduction and analysis
6. Control network calculations, analysis and adjustments
7. Determination of bearings/azimuths
8. Area/volume calculations
9. Horizontal and vertical alignment calculations
10. Construction staking calculations (e.g., plan interpretation)

D. Documentation 7%

1. Survey maps/plats
2. Survey reports
3. Descriptions

IV. Business/Professional Practices 15%

A. Project planning (e.g., parameters, costs)
B. Contracts
C. Risk management (e.g., liability, safety procedures, insurance)
D. Ethics
E. Communications (oral, written, graphical)
F. Quality assurance procedures

V. Types of Surveys 15%

A. ALTA/ACSM surveys
B. Control and geodetic surveys
C. Construction surveys (e.g., construction calculations and staking)
D. Boundary surveys
E. Route and right-of-way surveys
F. Topographic surveys by field methods
G. Topographic surveys by photogrammetry

APPENDIX B

EXAMPLES OF UNIT STUDY PLAN AND SUPPLEMENTAL CHAPTER NOTES

Unit 2 - Study Plan

Unit 2 - Study PlanÂ Unit 2 - Study Plan

Â Â

Â Study Assignment

Â Â

Â Study Chapter Three thoroughly. You might want to refer to the Supplemental Notes as you study.

Â Â

Â Supplemental Notes

Â Â

Â Review the Supplemental Notes for Chapter Three.

Â Â

Â Problems

Â Â

Â Work as many problems as you can at the end of Chapter 3.Â Refer back to the examples in the chapter for help.Â Be sure to work the problems which have answers given in the back of the book.Â (Even if you have to "work backwards" from the answer, this will help you to understand the theory.)

Â Â

Â Chapter Quiz

Â Â

Â Take the quiz on Unit 2 (go to the course homepage and click on the "Quizzes" icon).

You may use any references you wish on the chapter quiz, so long as they donâ€™t breathe.

Â Â

Â * * End Unit 2 * *

Supplemental Notes â€" Chapter TwoSupplemental Notes â€" Chapter Two
2-1 Introduction
We now have fancy equipment that makes measurements for us, but we need to understand what the equipment is doing.
2-2 Units of Measurement
In the coming years, surveyors will have more need to understand the two most common systems of Measurement, the English system and the SI (metric) system. The SI system, commonly called the metric system, is actually a hybrid of certain parts of the metric system. Theoretically, the SI system has only one unit for each dimension, so that even if the units were not specified, the user would know what the units for the dimension were. For example, the unit for length is the meter; a distance (length) stated as 30.43 would be understood to mean 30.43 meters.
This theoretical usage is not common, though, and we still indicate whatever the units are. You should always indicate the units when you give a measurement; that way there will be no misunderstanding.
As time goes on, surveyors will be more involved with conversion factors, converting between English and metric units.
We traditionally give length measurements in decimal feet, usually to two decimal places. We measure angles in degrees-minutes-seconds, further dividing the seconds with decimals if needed. Remember that degrees-minutes-seconds is not the same as decimal degrees. If we are doing calculations involving multiplication or division of angles, we need to convert to decimal degrees for the calculations.
The English system is a â€œgravitational systemâ€c and the SI is an â€œabsolute systemâ€i. The SI system can be used the same way on the moon as here on earth, since it does not need to take into account the effects of gravity. When converting units of force (example: pounds) between systems, the effect of gravity must be considered. We will not need to worry about all that in this course.
2-3Â International System of Units
The SI version of metric came into being around the middle of the 20th century. Notice the strange definition of the meter in the middle of page 26. With this new definition, the length of a meter could be exactly established with fancy laboratory equipment. Prior to that, the only exact meter was the international prototype bar in France.
There is still lots of opposition to converting to common usage of the SI system here in the United States. In some cases, organizations have had to revert to the English system. About fifteen years ago, the problems in some engineering statics textbooks were almost exclusively SI; they did not sell very well, so now they have lots of problems, many using English units and many using SI. Another example is the mileage signs on the Interstate Highways. Distances were posted in kilometers, but after public outcry, they stuck with miles.
2-4Â Significant Figures
Study this section carefully. Remember, significant figures and decimal places are two different things.
Trailing zeroes at the end of a quantity may or may not be significant; we usually need more information. For example, the population of Georgia might be stated as 8,000,000. This does not mean that there are exactly eight million people, but approximately eight million. In this case, the trailing zeroes are not significant. They are â€œimportantâ€t but they are not â€œsignificantâ€n from a mathematics standpoint.
In order to express a number in scientific notation, you move the decimal point to the left or right until there is only one digit to the left of the decimal point, and that digit must be anything but zero. Then, you multiply the new number by whatever power of ten to make it equal the old number. Here are two examples:

254.678 = 2.54678 x 102

0.004360 = 4.360 x 10-3 (4.360 times 1/1000)

Notice that in the second example, the trailing zero is included. Trailing zeroes after a decimal point in a quantity are considered significant.

of the digits in the quantities multiplied by powers of 10 (2.54678 and 4.360)are considered significant.

When multiplying or dividing quantities (page 28), the result should have no more significant digits than the quantity with the least number of significant digits.

Many conversion factors are exact numbers, and all of the digits are significant. An example is !2 inches = 1 foot. Follow the rules of section 4 on page 29, when converting. Your converted quantity should have the same number of significant digits as the quantity being converted.

2-5 Rounding Off Numbers

There is sometimes confusion when rounding off numbers. When you are dropping a set of numbers that begins with 5, look at the whole set. For instance, if you are rounding 2.36501 to two decimal places, you are dropping .00501 which is a little bit greater than .00500, so you would round up, and your answer should be 2.37. If you are rounding 2.36499 to two decimal places, you are dropping .00499 which is a little bit smaller than .00500, so you would round down, and your answer should be 2.36.Â Â Â Â Â Â Â If you are rounding 2.36500 to two decimal places, you would be dropping a number (.00500) which is exactly half way between 2.36 and 2.37. That's when you should follow Rule 2 on page 30, and your answer should be 2.36.

2-6Â â€“ 2-11 Field Notes

Your organization probably has a standard procedure for field notes. The ability to produce neat,
accurate, legible field notes is still a desirable trait.
These are very important sections, and you should study and apply them in your everyday work.

2-12 â€“ 2-15 Data Collectors

There are no supplementary notes for these sections.

APPENDIX C

COMMON QUESTION SELECTION TABLES

Table C.1 FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 1)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # correct per?	Act. % correct per?	Ranking	Selection
	Sum (4)		41	38	92.68		
	Sum (12)		40	31	77.50		
LM2-MQ2A UM 2	Sum (2)	2	40	39	97.50	Low	X
	Sum (quiz01_001)		40	39	97.50		
LM1-MQ1A Special 2	Sum (quiz01_002)	1	40	36	90.00	Low	X
LM1-MQ1A Special 1	Sum (quiz01_005)	1	40	40	100.00	High	X
LM2-MQ2A SF 3	Sum (13)	2	39	31	79.49	Med2	X
LM2-MQ2A SF 4	Sum (14)	2	39	26	66.67	Low	X
	Sum (19)		39	33	84.62		
	Sum (20)		39	37	94.87		
	Sum (quiz01_009)		39	24	61.54		
LM2-MQ2A UM 1	Sum (1)	2	38	38	100.00	High	X
	Sum (10)		38	27	71.05		
LM1-MQ1A Geo vs Plane 1	Sum (quiz01_003)	1	37	36	97.30	High	X
	Sum (15)		36	35	97.22		
LM2-MQ2A UC 3	Sum (3)	2	36	28	77.78	Med2	X
	Sum (5)		36	28	77.78		
	Sum (7)		36	26	72.22		
LM2-MQ2A SF 2	Sum (16)	2	35	29	82.86	Med1	X
	Sum (quiz01_006)		35	31	88.57		
	Sum (quiz01_007)		35	28	80.00		
LM2-MQ2A UC 4	Sum (6)	2	34	19	55.88	Low	X
LM2-MQ2A UC 1	Sum (8)	2	34	34	100.00	High	X
	Sum (11)		33	25	75.76		
	Sum (quiz01_011)		33	33	100.00		
LM2-MQ2A SF 1	Sum (17)	2	32	29	90.63	High	X
	Sum (18)		32	29	90.63		
	Sum (quiz01_010)		32	30	93.75		
LM2-MQ2A UC 2	Sum (9)	2	31	26	83.87	Med1	X
	Sum (quiz01_008)		31	28	90.32		
LM1-MQ1A Geo vs Plane 2	Sum (quiz01_004)	1	30	28	93.33	Low	X

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.2 FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 2)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (16)		54	54	100		
	Sum (18)		54	54	100		
LM15-MQ15A ST & MES	Sum (17)	3	54	53	98	Med	X
	Sum (20)		54	52	96		
LM15-MQ15A PES-WM	Sum (12)	3	54	52	96	High	X
	Sum (9)		54	51	94		
	Sum (1)		54	50	93		
	Sum (19)		54	50	93		
	Sum (11)		54	50	93		
	Sum (14)		54	48	89		
LM15-MQ15A PES-%E	Sum (3)	3	54	48	89	Med	X
	Sum (7)		54	48	89		
	Sum (6)		54	47	87		
	Sum (13)		54	47	87		
	Sum (4)		54	47	87		
LM15-MQ15A PES-EOS	Sum (10)	3	54	45	83	Med	X
	Sum (5)		54	44	81		
	Sum (8)		54	43	80		
	Sum (2)		54	40	74		
	Sum (15)		54	39	72		

Ch. = Chapter, N = Number of Question Occurrences, Act. # Correct per ? = Actual Number of Response Correct per Question, Act. % correct per ? = Actual Percentage of Responses Correct per Question

Table C.3 FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 3)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
LM3-MQ3A LD 1	Sum (12)	4	55	55	100	High	X
	Sum (13)		55	55	100		
	Sum (14)		55	55	100		
	Sum (5)		55	55	100		
	Sum (9)		55	55	100		
LM3-MQ3A DLP 1	Sum (17)	4	55	54	98	High	X
LM3-MQ3A DLP 2	Sum (20)	4	55	54	98	Low	X
	Sum (10)		55	53	96		
	Sum (3)		55	52	95		
	Sum (4)		55	51	93		
	Sum (11)		55	51	93		
LM3-MQ3A LD 2	Sum (7)	4	55	50	91	Low	X
LM3-MQ3A C&R 1	Sum (2)	4	55	48	87	Med	X
LM3-MQ3A Datums 1	Sum (18)	4	55	47	85	High	X
LM3-MQ3A C&R 2	Sum (15)	4	55	46	84	Low	X
LM3-MQ3A TLP 1	Sum (16)	4	55	30	55	Only	X

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.4A FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 4)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (01 2)		55	29	52.7		
LM4-MQ4A LP 2	Sum (7)	5	36	16	44.4	Low	X
	Sum (17 2)		35	25	71.4		
LM4-MQ4A LMA 1	Sum (05 2)	5	33	18	54.5	Med2	X
	Sum (19 2)		32	16	50.0		
LM4-MQ4A LCC 2	Sum (10)	5	31	16	51.6	Low	X
	Sum (13)		30	23	76.7		
	Sum (16)		30	24	80.0		
	Sum (19)		30	19	63.3		
	Sum (12)		29	21	72.4		
	Sum (16 2)		29	22	75.9		
	Sum (18)		29	27	93.1		
	Sum (20)		29	18	62.1		
	Sum (3)		29	23	79.3		
LM4-MQ4A LP 1	Sum (6)	5	29	22	75.9	Med	X
LM5-MQ5A EDM SD 1	Sum (06 2)	6	28	25	89.3	High	X
	Sum (14)		28	20	71.4		
LM4-MQ4A FEOC 1	Sum (03 2)	5	27	17	63.0	Med2	X
	Sum (11 2)		27	16	59.3		
	Sum (11)		27	22	81.5		
	Sum (08 2)		26	17	65.4		
LM5-MQ5A EDM E & A 1	Sum (13 2)	6	26	18	69.2	Med	X
	Sum (15 2)		26	13	50.0		
	Sum (18 2)		26	11	42.3		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.4B FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 4)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
LM4-MQ4A FEOC 2	Sum (2)	5	26	16	61.5	Low	X
LM4-MQ4A LCC 1	Sum (8)	5	26	15	57.7	Med	X
	Sum (04 2)		25	13	52.0		
	Sum (10 2)		25	13	52.0		
	Sum (5)		25	20	80.0		
LM4-MQ4A LMA 2	Sum (15)	5	24	11	45.8	Low	X
	Sum (17)		24	22	91.7		
	Sum (4)		24	19	79.2		
LM5-MQ5A EDM SD 2	Sum (07 2)	6	23	14	60.9	Low	X
LM5-MQ5A EDM E & A 2	Sum (14 2)	6	23	8	34.8	Low	X
	Sum (09 2)		22	16	72.7		
	Sum (1)		22	16	72.7		
	Sum (12 2)		22	17	77.3		
	Sum (9)		22	16	72.7		
LM5-MQ5A TP 2	Sum (02 2)	6	20	10	50.0	Low	X
	Sum (20 2)		20	20	100.0		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.5A FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 5)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (1)		55	52	94.55		
	Sum (06 2)		33	23	69.70		
LM7-MQ7A MONTS 3	Sum (12 2)	8	32	21	65.63	Med2	X
LM6-MQ6A U & K HAM 1	Sum (15)	7	32	29	90.62	Low	X
	Sum (8)		32	27	84.37		
	Sum (18 2)		31	22	70.96		
LM6-MQ6A BSP 2	Sum (3)	7	31	16	51.61	Low	X
LM7-MQ7A RA&D 1	Sum (05 2)	8	30	19	63.33	Med	X
LM6-MQ6A BSP 1	Sum (12)	7	30	25	83.33	Med1	X
	Sum (16 2)		30	25	83.33		
	Sum (20 2)		30	19	63.33		
	Sum (02 2)		29	20	68.97		
LM6-MQ6A MDP 2	Sum (2)	7	29	17	58.62	Low	X
	Sum (09 2)		28	28	100.00		
LM7-MQ7A MONTS 4	Sum (13 2)	8	28	18	64.29	Med1	X
	Sum (04 2)		27	18	66.67		
	Sum (07 2)		27	14	51.85		
	Sum (10)		27	17	62.96		
LM7-MQ7A MONTS 1	Sum (11 2)	8	27	9	33.33	Low	X
	Sum (16)		27	26	96.30		
	Sum (19 2)		27	21	77.78		
	Sum (19)		27	20	74.07		
LM7-MQ7A MONTS 2	Sum (9)	8	27	13	48.15	Med	X
LM7-MQ7A RA&D 2	Sum (01 2)	8	26	14	53.85	Low	X

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.5B FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 5)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (03 2)		26	16	61.54		
	Sum (08 2)		26	26	100.00		
	Sum (17 2)		26	19	73.08		
LM6-MQ6A MDP 1	Sum (7)	7	26	19	73.08	Med2	X
LM6-MQ6A U & K HAM 2	Sum (13)	7	25	24	96.00	Med1	X
	Sum (14)		25	24	96.00		
	Sum (6)		25	19	76.00		
	Sum (14 2)		24	12	50.00		
	Sum (20)		24	19	79.17		
	Sum (11)		23	16	69.57		
	Sum (15 2)		23	19	82.61		
	Sum (4)		23	22	95.65		
	Sum (5)		21	19	90.47		
	Sum (10 2)		20	20	100.00		
	Sum (17)		19	13	68.42		
	Sum (18A)		18	5	27.78		
	Sum (18)		4	1	25.00		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.6A FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 6)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
LM10- Q10A LMRPC 1	Sum (08 2)	10	54	53	98.1	High	X
	Sum (16)		36	33	91.7		
	Sum (10)		33	27	81.8		
	Sum (03 2)		32	27	84.4		
LM10-Q10A TAC 2	Sum (3)	10	32	30	93.8	Med	X
	Sum (05 2)		31	24	77.4		
	Sum (06 2)		31	21	67.7		
	Sum (18)		31	30	96.8		
	Sum (11)		29	23	79.3		
	Sum (13)		29	28	96.6		
	Sum (15)		29	17	58.6		
	Sum (8)		29	21	72.4		
LM9-MQ9A MAIT 3	Sum (14)		28	28	100.0	High	X
LM9-MQ9A MAIT 1	Sum (16 2)	9	28	23	82.1	Low	X
	Sum (17 2)		28	23	82.1		
LM9-MQ9A AMIT 2	Sum (7)	9	28	24	85.7	Med	X
	Sum (02 2)		27	19	70.4		
LM10-Q10A TAC 1	Sum (1)	10	27	25	92.6	High	X
LM10-Q10A LMRPC 2	Sum (10 2)	10	26	16	61.5	Med	X
	Sum (13 2)		26	23	88.5		
	Sum (17)		26	24	92.3		
LM9-MQ9A AMIT 1	Sum (2)	9	26	16	61.5	Low	X
	Sum (20 2)		26	22	84.6		
	Sum (5)		26	17	65.4		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.6B FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 6)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
LM9-MQ9A AMIT 3	Sum (01 2)	9	25	25	100.0	High	X
	Sum (4)		25	24	96.0		
	Sum (09 2)		24	19	79.2		
LM10-Q10A LMRPC 3	Sum (11 2)	10	24	14	58.3	Low	X
	Sum (18 2)		24	19	79.2		
	Sum (19 2)		24	18	75.0		
	Sum (20)		24	23	95.8		
	Sum (07 2)		23	20	87.0		
	Sum (15 2)		23	21	91.3		
LM10-Q10A TAC 3	Sum (04 2)	10	22	7	31.8	Low	X
	Sum (12)		22	22	100.0		
	Sum (14 2)		22	14	63.6		
	Sum (19)		22	22	100.0		
	Sum (12 2)		20	9	45.0		
	Sum (6)		19	17	89.5		
	Sum (9)		19	15	78.9		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.7A FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 7)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (03-code)		53	52	98.11		
	Sum (02 2)		39	38	97.48		
	Sum (17 2)		34	33	97.06		
	Sum (16 2)		33	18	54.55		
	Sum (16)		32	23	71.88		
	Sum (08 2)		31	23	74.19		
	Sum (10 2)		31	28	90.32		
	Sum (15)		30	18	60.00		
LM12-Q12A ABC	Sum (12 2)	12	29	19	65.52	Low	X
	Sum (13)		28	15	53.57		
	Sum (5)		27	20	74.07		
	Sum (10)		27	15	55.56		
	Sum (18)		27	16	59.26		
	Sum (13 2)		27	20	74.07		
	Sum (19 2)		27	19	70.37		
	Sum (14)		26	21	80.77		
	Sum (17)		26	19	73.08		
	Sum (20)		26	21	80.77		
	Sum (01 2)		26	22	84.62		
	Sum (07 2)		26	22	84.61		
LM11-Q11A COGO 3	Sum (09 2)	11	26	20	76.93	Med	X
LM11-Q11A COGO 1	Sum (1)	11	25	18	72.00	Med	X
LM12-Q12A T3S	Sum (3)	12	25	24	96.00	Med	X

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.7B FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 7)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (7)		25	17	68.00		
	Sum (9)		25	19	76.00		
	Sum (04 2)		25	21	84.00		
	Sum (20 2)		25	23	92.00		
	Sum (2)		24	15	62.50		
	Sum (11)		24	19	79.17		
LM12-Q12A DMD	Sum (06 2)	12	24	18	75.00	Med	X
	Sum (18 2)		24	19	79.17		
	Sum (19)		23	20	86.96		
LM11-Q11A COGO 2	Sum (11 2)	11	23	15	65.22	Med	X
	Sum (8)		22	18	81.82		
	Sum (4)		21	14	66.67		
	Sum (12)		21	13	61.90		
LM12-Q12A SAP	Sum (15 2)	12	20	16	80.00	Med	X
	Sum (05 2)		19	14	73.69		
	Sum (6)		18	16	88.89		
	Sum (14 2)		16	12	75.00		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.8A FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 8)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (14 2)		34	26	76.47		
	Sum (08 2)		31	27	87.09		
LM14-Q14A SBD	Sum (15)	13	31	31	100.00	High	X
	Sum (16)		31	25	80.65		
	Sum (10)		30	20	66.67		
	Sum (16 2)		30	20	66.67		
	Sum (11)		29	27	93.10		
	Sum (18)		29	29	100.00		
LM14-Q14A GPS CSCH	Sum (5)	13	29	21	72.41	Med	X
	Sum (15 2)		28	24	85.72		
	Sum (20 2)		28	28	100.00		
	Sum (7)		28	22	78.57		
	Sum (01 2)		27	24	88.89		
	Sum (13 2)		27	22	81.48		
	Sum (17 2)		27	22	81.48		
	Sum (17)		27	25	92.59		
	Sum (20)		27	24	88.89		
LM14-Q14A GPS CSCC	Sum (9)	13	27	21	77.78	Med	X
	Sum (18 2)		26	25	96.15		
	Sum (18)		26	26	100.00		
	Sum (4)		26	20	76.92		
LM14-Q14A RCS	Sum (6)	13	26	20	76.93	Med	X
	Sum (8)		26	19	73.08		
	Sum (07 2)		25	22	88.00		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

Table C.8B FSG Course (2501) Spring 2012 – Fall 2013 D2L Common Question Selection (Unit 8)

Question Name	Title from Excel: Sum ()	Ch.	N (Des)	Act. # Correct per ?	Act. % correct per ?	Ranking	Selection
	Sum (12 2)		25	23	92.00		
	Sum (14)		25	14	56.00		
	Sum (03 2)		24	23	95.83		
	Sum (06 2)		24	23	95.83		
	Sum (1)		24	18	75.00		
	Sum (12)		24	18	75.00		
	Sum (19 2)		24	21	87.50		
	Sum (04 2)		23	23	100.00		
	Sum (05 2)		23	23	100.00		
	Sum (09 2)		23	22	95.65		
	Sum (02-code)		21	19	90.48		
	Sum (10 2)		21	17	80.95		
	Sum (11 2)		19	13	68.42		
	Sum (13)		18	16	88.89		
	Sum (2)		18	15	83.33		
	Sum (3)		9	5	55.56		

Ch. = Chapter, **N** = Number of Question Occurrences, **Act. # Correct per ?** = Actual Number of Response Correct per Question, **Act. % correct per ? =** Actual Percentage of Responses Correct per Question

APPENDIX D

STUDENT FSG COURSE PERFROMANCE PREDICTION

In this study, it was recognized that the prediction of the s-g students' performances in the FSG course would be useful as a comparison tool for the experimental and control course offerings. Thus, two tracts of analysis were pursued. The first track was based on student characterization data and the second track was based on student CQQ performance & related grouping.

D.1 FSG Course Student Performance Prediction based on Student Characterization Data

After a careful consideration of the available student characterization variables, multivariate regression was selected as the method to predict the student numeric grade in the FSG course (SURV 2501). The variables chosen for the analysis, as defined in Table D.1 below, were selected after the student characterization was developed in Chapter 6 of this study. Only the Introductory Data group had adequate numbers of students with appropriate values in each variable category. Thus, data from fifty students in the Introductory Group was utilized in the analysis.

Table D.1 S-G Student Variables for Performance Prediction

Variable Code Name	Variable Name	Variable Type
Age	Student Age	Scale-Floating Point Variable
HSGPA	High School Grade Point Average	Scale-Floating Point Variable
GN15001112	SURV 1500/MATH 1112 Grades Numeric-Midpoint	Scale-Floating Point Variable
GN2501	SURV 2501 Grades Numeric-Midpoint	Scale-Floating Point Variable
ICCH	Institution Cumulative Credit Hours	Scale-Floating Point Variable
IGPA	Institution Grade Point Average	Scale-Floating Point Variable

- Student Age: The Student Age is defined as the student's age in years at the beginning of the first semester. (Scale-Floating Point Variable)
- High School Grade Point Average: The Student's High School Grade Point Average (HSGPA) is the student's grade average at the completion of High School based on a 0 to 4.0 scale. (Scale-Floating Point Variable)
- GN15001112: Student's numeric grade in SURV 1500, Elementary Surveying Calculations or MATH 1112, College Trigonometry as determined from midpoint of letter grade range. (i.e. GN1500/1112 = 75 as derived from a recorded "C" grade) (Scale-Floating Point Variable)
- GN2501: Student's numeric grade in SURV 2501, Plane Surveying as determined from midpoint of letter grade range. (i.e. GN2501 = 85 as derived from a recorded "B" grade) (Scale-Floating Point Variable)
- Institution Cumulative Credit Hours: The student's Institution Cumulative Credit Hours (ICCH) at Middle Georgia State College represents the accumulated credit hours for courses taken at Middle Georgia State College. The ICCH includes

credit hours for all the courses taken at MGSC by the date of the recent query, January 14, 2014. (Scale-Floating Point Variable)

- Institution Grade Point Average: The Student's Institutional Grade Point Average is the Cumulative Grade Point Average at Middle Georgia State College. This average is determined by dividing the Institution Quality Points by the Total Credit Hours taken (for credit). This average can be adjusted for courses that are repeated where the grade in the new grade is higher than the previous grade. (Scale-Floating Point Variable)

D.1.1 Initial Pearson Correlation Review

As a beginning point, the correlation among the six variables was tested for significance as this test will be helpful in setting up the regression analysis. Thus, an initial Pearson Correlation review was run and the test as shown in Table D.2 below indicated that IGPA & GN15001112 were significantly correlated to GN2501. The other variables were not significant in correlation which is disappointing since this step eliminated all but one pre-course variables in the regression analysis. If all of the data (variables) was required of the s-g students as they entered the s-g program, perhaps enough data could be available to establish pre-course performance correlation with the FSG course performance.

Table D.2 Pearson Correlation Analysis- Data

		AGE	HSGPA	IGPA	GN15001112	GN2501	ICCH
AGE	Pearson Correlation	1	-.303*	.111	-.269	.174	-.005
	Sig. (2-tailed)		.032	.443	.059	.228	.975
	N	50	50	50	50	50	50
HSGPA	Pearson Correlation	-.303*	1	.170	.147	-.015	.004
	Sig. (2-tailed)	.032		.238	.310	.916	.978
	N	50	50	50	50	50	50
IGPA	Pearson Correlation	.111	.170	1	.466**	.642**	.378**
	Sig. (2-tailed)	.443	.238		.001	.000	.007
	N	50	50	50	50	50	50
GN15001112	Pearson Correlation	-.269	.147	.466**	1	.393**	.206
	Sig. (2-tailed)	.059	.310	.001		.005	.151
	N	50	50	50	50	50	50
GN2501	Pearson Correlation	.174	-.015	.642**	.393**	1	.119
	Sig. (2-tailed)	.228	.916	.000	.005		.410
	N	50	50	50	50	50	50
ICCH	Pearson Correlation	-.005	.004	.378**	.206	.119	1
	Sig. (2-tailed)	.975	.978	.007	.151	.410	
	N	50	50	50	50	50	50
*. Correlation is significant at the 0.05 level (2-tailed).							
**. Correlation is significant at the 0.01 level (2-tailed).							

D.1.2 Regression Run

Multiple variable combinations were tried but the final selected combination included only the independent IGPA variable and the dependent GBN2501 variable. See results in Tables D.3 & D.4. This step eliminated all of the pre-course variables. The R square value of 0.412 indicates a moderate correlation. The constant (intercept) value (66.0) and the slope (5.503) of the prediction equation were determined from the regression analysis and are shown in Table D.4. The application the prediction equation was developed below.

Table D.3 Regression Results for SURV 2501 Grade Prediction

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.642[a]	.412	.400	4.18691

a. Predictors: (Constant), IGPA

b. Dependent Variable: GN2501

Table D.4 Regression Results for SURV 2501 Grade Prediction

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	65.985	2.587		25.509	.000
	IGPA	5.503	.948	.642	5.804	.000

a. Dependent Variable: GN2501

D.1.3 Derived Prediction Equation

The derived grade prediction equation was developed as follows:

$$\mathbf{Y = 5.503X_1 + 66.0}$$

Where X_1 = IGPA and Y = the predicted numeric score of GN2501

An example scenario was proposed to check the results of the equation as follows: An S-G student has an IGPA = 2.8 and it is desired that the student's score in the FSG course be predicted. Applying this IGPA value to the grade prediction equation, the predicted score is 81.4 +/- 5 points. (Y = (5.503*2.8) + 66.0) It should be noted that the variation introduced by utilizing the midpoint score for the GN2501 variable serves to weaken the value of the prediction.

D.1.4 Probability of Grade Occurrence

In order to reinforce the prediction of scores for the FSG course, crosstabs analysis as provided by the SPSS statistics software application was executed as shown in Table D.5. It was seen how the increase in probability grows for the student to make a “B” or higher in GN2501 (SURV 2501-FSG Course) if the student makes a “B” or higher in GN15001112. (Example: The probability for a “B” grade in GN2501 grows from 10% with a “C” in GN15001112 up to a range of 26% - 42% with a “B” to "A” in GN15001112.)

Table D.5 CrossTabs Analysis for SURV 2501 Grade Prediction

			GN15001112			Total
			75.00	85.00	95.00	
GN2501	75.00	Count	9	13	1	23
		% within GN2501	39.1%	56.5%	4.3%	100.0%
		% within GN15001112	64.3%	50.0%	10.0%	46.0%
		% of Total	18.0%	26.0%	2.0%	46.0%
	85.00	Count	5	13	8	26
		% within GN2501	19.2%	50.0%	30.8%	100.0%
		% within GN15001112	35.7%	50.0%	80.0%	52.0%
		% of Total	10.0%	26.0%	16.0%	52.0%
	95.00	Count	0	0	1	1
		% within GN2501	.0%	.0%	100.0%	100.0%
		% within GN15001112	.0%	.0%	10.0%	2.0%
		% of Total	.0%	.0%	2.0%	2.0%
Total		Count	14	26	10	50
		% within GN2501	28.0%	52.0%	20.0%	100.0%
		% within GN15001112	100.0%	100.0%	100.0%	100.0%
		% of Total	28.0%	52.0%	20.0%	100.0%

D.2 FSG Course Student Performance Prediction based on Common Quiz Question Performance

In addition to the FSG course performance based on student characterization data, the FSG course performance was evaluated based on responses to selected groups of Common Quiz Questions. Thus, the rich 73 quiz question database will be broken down further to see if the student performance in the FSG course can be correlated to the Final Grade Numeric. Also, the evaluation will be used to help better understand changes in performance between the Control and Experimental student groups.

D.2.1 Reducing the CCQs to emphasize Questions showing a Positive Increase in Percent Correct

Initially, the seventy-three CCQs are evaluated to determine which questions showed a +Correct % increase when comparing the control group to the experimental group. This effort reduces the CQQ set to 48 questions which is a more manageable number and runs consistently with the purpose of the treatment changes provided in the experimental course offerings. The question list for these 48 questions is given in Table D.6 below. It was noted that with the table sorted from high to low, the question ranking works in the opposite direction generally from low to high.

Table D.6 Forty-Eight CQQs with + % Correct Increase

Question Name	Ch.	Ranking	Max "AFL" - "AOL" Act. % correct per ?
LM4-MQ4A FEOC 2	5	Low	38.5
LM4-MQ4A FEOC 1	5	Med2	37
LM6-MQ6A MDP 2	7	Low	34.28
LM2-MQ2A UC 4	2	Low	34.12
LM4-MQ4A LP 2	5	Low	30.6
LM10-Q10A LMRPC 3	10	Low	27.4
LM6-MQ6A BSP 2	7	Low	26.99
LM10-Q10A TAC 3	10	Low	25.3
LM5-MQ5A TP 2	6	Low	25
LM2-MQ2A UC 3	2	Med2	22.22
LM4-MQ4A LMA 2	5	Low	20.9
LM3-MQ3A TLP 1	4	Only	20
LM6-MQ6A MDP 1	7	Med2	19.82
LM9-MQ9A AMIT 1	9	Low	18.5
LM11-Q11A COGO 2	11	Med	18.08
LM9-MQ9A MAIT 1	9	Low	17.9
LM11-Q11A COGO 3	11	Med	17.47
LM4-MQ4A LCC 1	5	Med	17.3
LM11-Q11A COGO 1	11	Med	16.9
LM10-Q10A LMRPC 2	10	Med	16.3
LM14-Q14A GPS CSCC	13	Med	16.02
LM4-MQ4A LMA 1	5	Med2	15.5
LM5-MQ5A EDM E & A 2	6	Low	15.2
LM5-MQ5A EDM SD 2	6	Low	14.1
LM7-MQ7A RA&D 2	8	Low	12.85
LM7-MQ7A RA&D 1	8	Med	11.67
LM5-MQ5A EDM E & A 1	6	Med	10.8
LM1-MQ1A Special 2	1	Low	10
LM12-Q12A SAP	12	Med	10
LM9-MQ9A AMIT 2	9	Med	9
LM7-MQ7A MONTS 1	8	Low	8.37
LM12-Q12A DMD	12	Med	8.3
LM3-MQ3A C&R 2	4	Low	7.7
LM1-MQ1A Geo vs Plane 2	1	Low	6.67
LM2-MQ2A SF 2	2	Med1	6.64
LM2-MQ2A UC 2	2	Med1	6.13
LM14-Q14A RCS	13	Med	4.87
LM12-Q12A ABC	12	Low	4.48
LM6-MQ6A BSP 1	7	Med1	4.17
LM6-MQ6A U & K HAM 1	7	Low	4.08
LM6-MQ6A U & K HAM 2	7	Med1	4
LM1-MQ1A Geo vs Plane 1	1	High	2.7
LM2-MQ2A UM 2	2	Low	2.5
LM3-MQ3A DLP 1	4	High	2
LM3-MQ3A DLP 2	4	Low	2
LM15-MQ15A ST & MES	3	Med	2
LM10- Q10A LMRPC 1	10	High	1.9
LM7-MQ7A MONTS 3	8	Med2	1.07

D.2.2 Additional Question Selection to Further Reduce the 48 CQQ Group: Unit Tests

As desired, in an effort to make the question group smaller, more efficient and more predictive, it was decided to determine which Unit Tests exhibited plot distributions more conducive to correlation with the students' final grade. Thus, scatter plots comparing the students Unit Test-Module Quiz scores were developed. A minimum scatter plot correlation of approximately 0.3 was used as the selection criteria. Figures D.1, D.2 and D.3 contain the scatter plots for the Unit Tests (control group) that were selected.

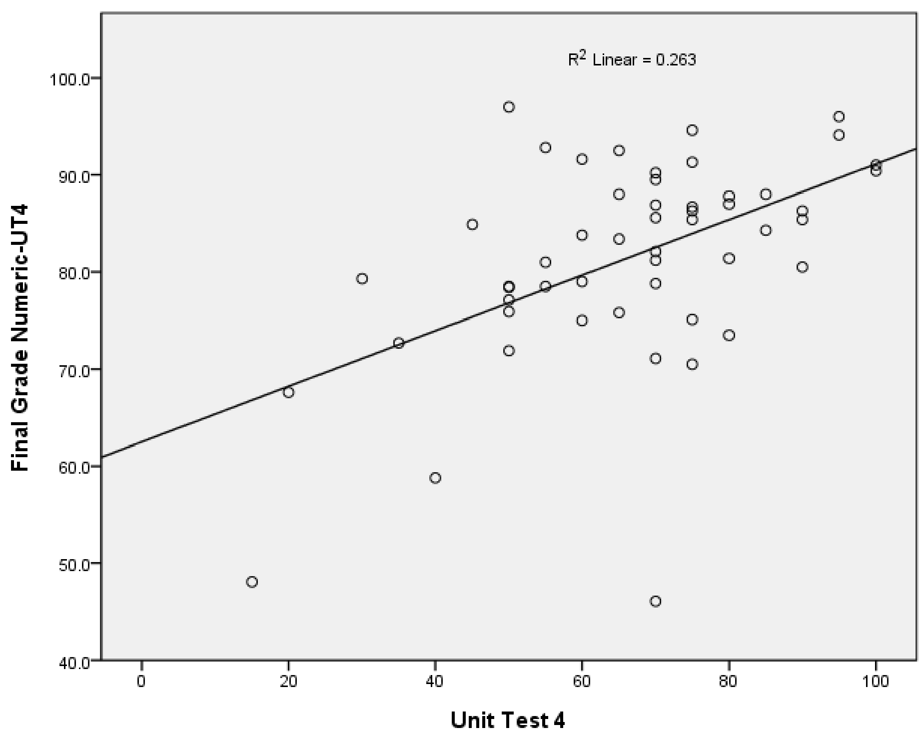


Figure D.1 Unit Test Score vs. FSG Course Final Grade Numeric

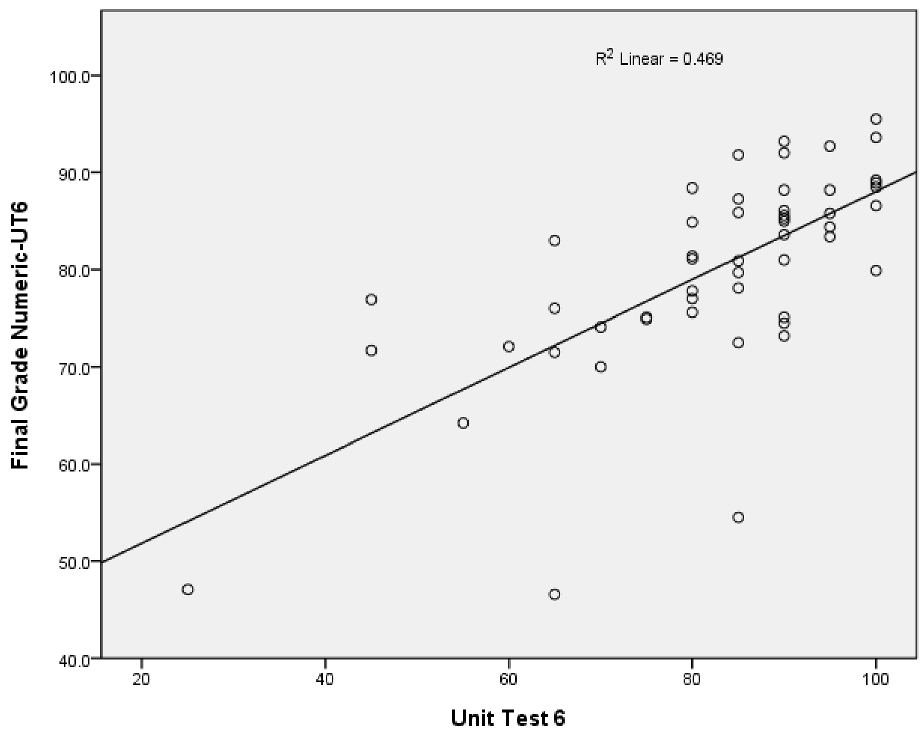


Figure D.2 Unit Test Score vs. FSG Course Final Grade Numeric

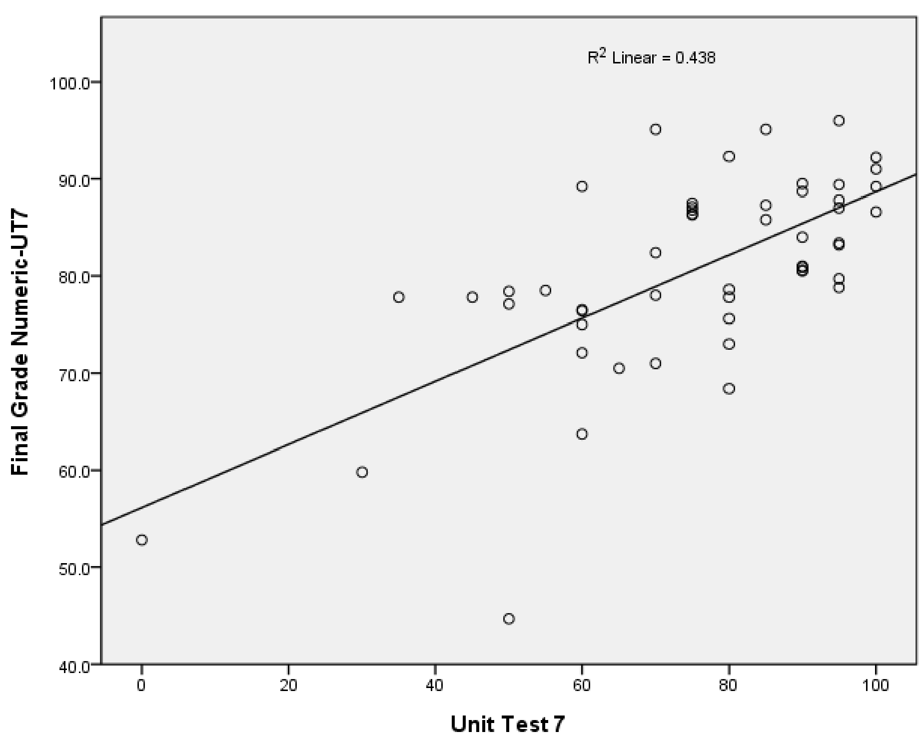


Figure D.3 Unit Test Score vs. FSG Course Final Grade Numeric

Next, utilizing the selected FSG Unit Test Scores and the Final Grade Numeric, a stepwise regression was run to determine the correlation between the variables. The results of the regression are shown in Tables D.7A and D.7B. The combination of all three Unit Tests shows the greatest degree of correlation with an adjusted R Square value of 0.814.

Table D.7A Regression Results Control Group:
Unit Test Score vs. FSG Course Final Grade Numeric

Model Summary[d]					
Model		R	R Square	Adjusted R Square	Std. Error of the Estimate
	1	.753[a]	.566	.558	6.9953
	2	.868[b]	.754	.744	5.3199
	3	.908[c]	.825	.814	4.5373

a. Predictors: (Constant), Quiz 07

b. Predictors: (Constant), Quiz 07, Quiz 06

c. Predictors: (Constant), Quiz 07, Quiz 06, Quiz 04

d. Dependent Variable: FG Num

Table D.7B Regression Results Control Group:
Unit Test Score vs. FSG Course Final Grade Numeric

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	51.250	3.710		13.816	.000		
	Quiz 07	.384	.047	.753	8.083	.000	1.000	1.000
2	(Constant)	33.468	4.050		8.264	.000		
	Quiz 07	.256	.042	.502	6.145	.000	.750	1.333
	Quiz 06	.333	.054	.500	6.120	.000	.750	1.333
3	(Constant)	30.448	3.522		8.646	.000		
	Quiz 07	.244	.036	.478	6.833	.000	.745	1.342
	Quiz 06	.244	.051	.367	4.817	.000	.630	1.587
	Quiz 04	.170	.039	.304	4.400	.000	.764	1.308

a. Dependent Variable: FG Num

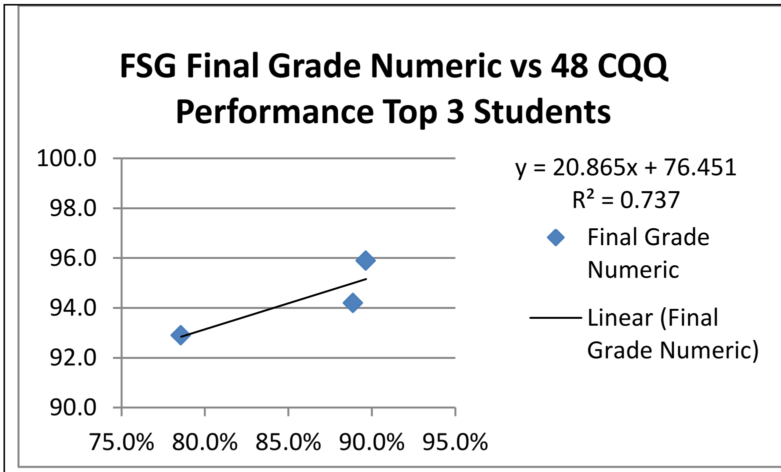
Based on a favorable regression as shown above, the 48 question group was reduced to only the questions contained in the most predictive chapters. The results of this selection reduced the question group to 18 questions as shown in Table D.8 below:

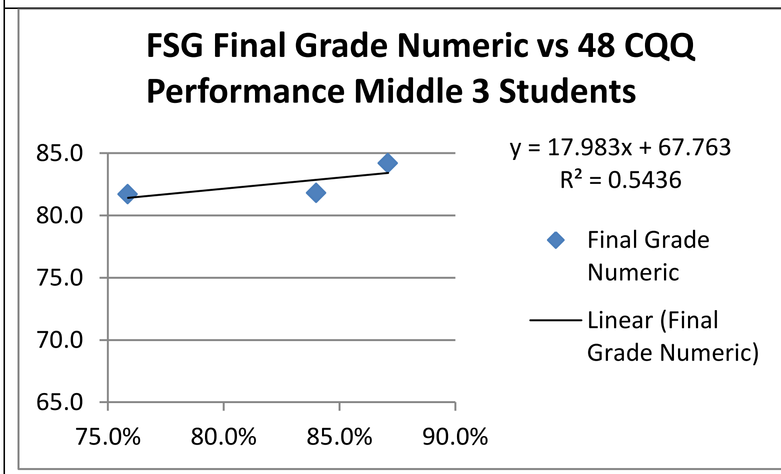
Table D.8 Eighteen Question Group based on Unit -Test Correlation (Control)

Question Name	Ch.	Ranking	+ Increase in % correct per?
LM4-MQ4A FEOC 1	5	Med2	37
LM4-MQ4A FEOC 2	5	Low	38.5
LM4-MQ4A LCC 1	5	Med	17.3
LM4-MQ4A LMA 1	5	Med2	15.5
LM4-MQ4A LMA 2	5	Low	20.9
LM9-MQ9A AMIT 1	9	Low	18.5
LM9-MQ9A AMIT 2	9	Med	9
LM9-MQ9A MAIT 1	9	Low	17.9
LM10- Q10A LMRPC 1	10	High	1.9
LM10-Q10A LMRPC 2	10	Med	16.3
LM10-Q10A LMRPC 3	10	Low	27.4
LM10-Q10A TAC 3	10	Low	25.3
LM11-Q11A COGO 1	11	Med	16.9
LM11-Q11A COGO 2	11	Med	18.08
LM11-Q11A COGO 3	11	Med	17.47
LM12-Q12A ABC	12	Low	4.48
LM12-Q12A DMD	12	Med	8.3
LM12-Q12A SAP	12	Med	10

In order to review the predictability of this question group, the top, middle and bottom three student performances representing the control course offerings were selected and applied to the full 48 question group and the reduced 18 question group. The results of the analysis are shown in Tables D.9 and D.10. A review of the tables shows more consistent behavior for the 48 CQQ set in all three student categories. The behavior for the 18 question group is sporadic with low correlation and wide data scatter, particularly in the Bottom 3 student group. At this point, for the control data set, it was decided that any prediction of the Final Grade Numeric should be limited to the 48 CQQ group. The poor correlation for the 18 CQQ was probably due to the small number of CQQs that were actually offered to the student due to the randomization of questions in the control course offerings.

Table D.9 Results of FSG Final Grade Numeric vs 48 CQQ (Control)





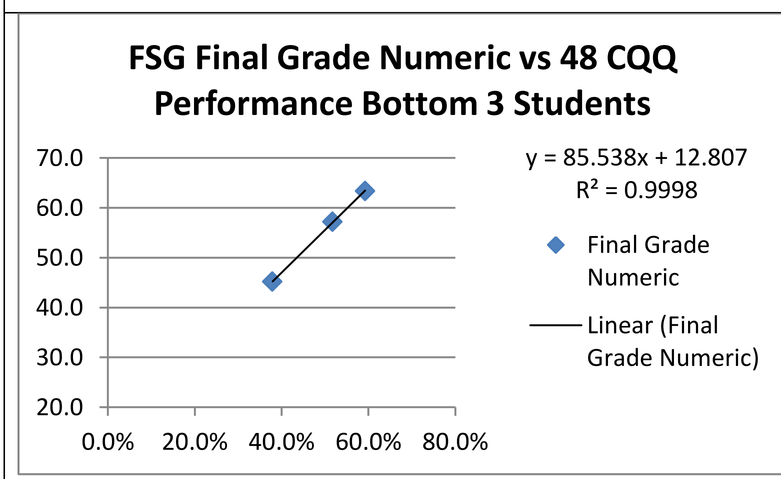
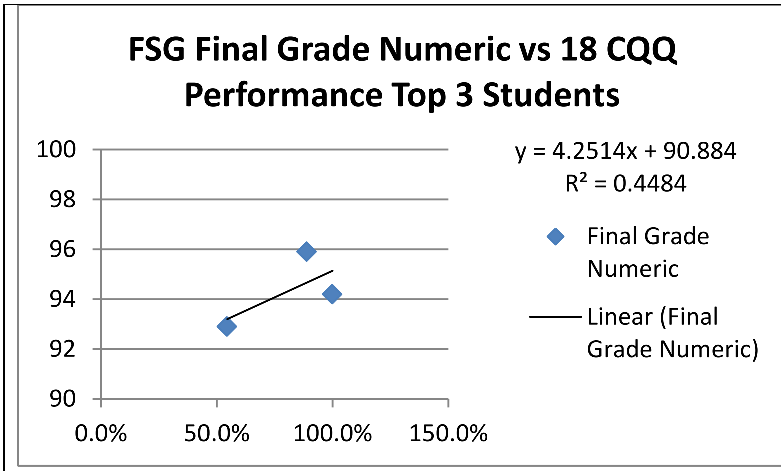
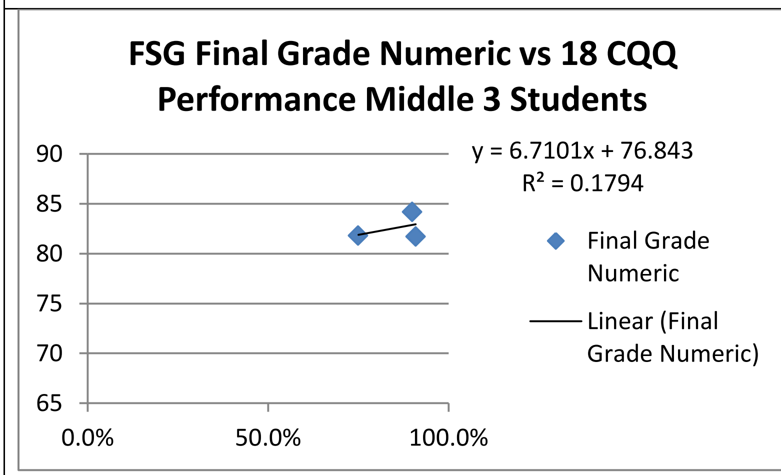
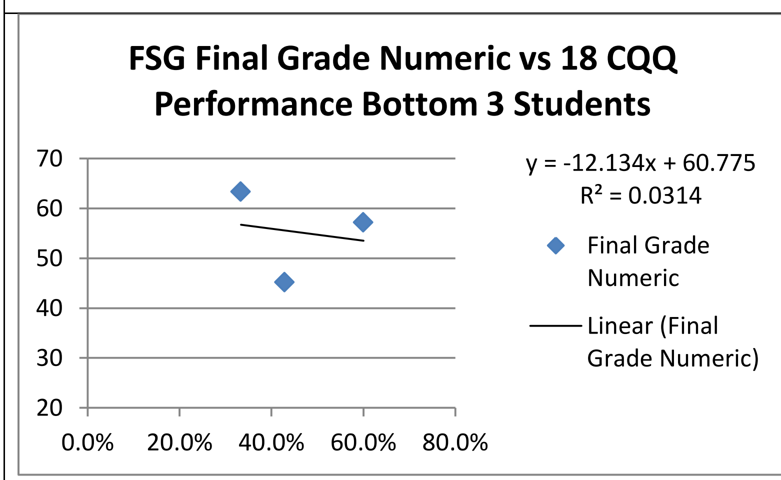


Table D.10 Results of FSG Final Grade Numeric vs 18 CQQ (Control)







D.2.3 Additional Question Selection to Further Reduce the 48 CQQ Group: Module Quizzes

As with the control course offerings, it was desirable to make the question group smaller, more efficient and more predictive for analysis in the experimental course offerings. Thus, it was decided to determine which Module Quizzes exhibited plot distributions more conducive to correlation with the students' final grade numeric. To facilitate the effort, scatter plots comparing the students' performance in the Module Quizzes versus Final Grade Numeric were developed. A minimum scatter plot correlation of approximately 0.4 was used as the selection criteria. Figures D.4 and D.5 contain the scatter plots for the Module Quizzes (Experimental Group) that were selected.

Next, utilizing the selected FSG Module Quiz Scores and the Final Grade Numeric, a stepwise regression was run to determine the correlation between the variables. The results of the regression are shown in Tables D.11A and D.11B. The combination of all three quizzes shows the greatest degree of correlation with an adjusted R Square value of 0.864.

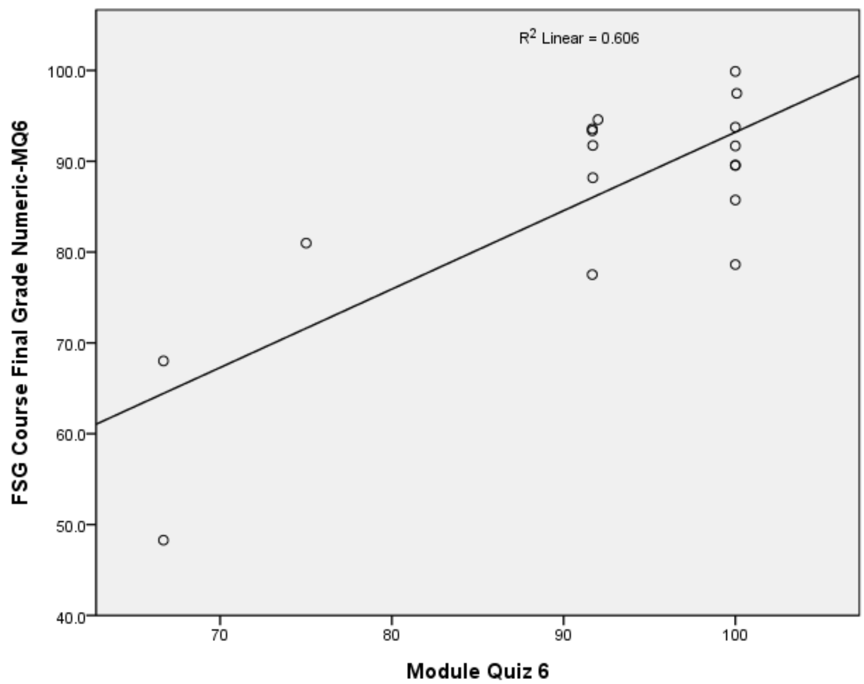


Figure D.4 Module Quiz Score vs. FSG Course Final Grade Numeric

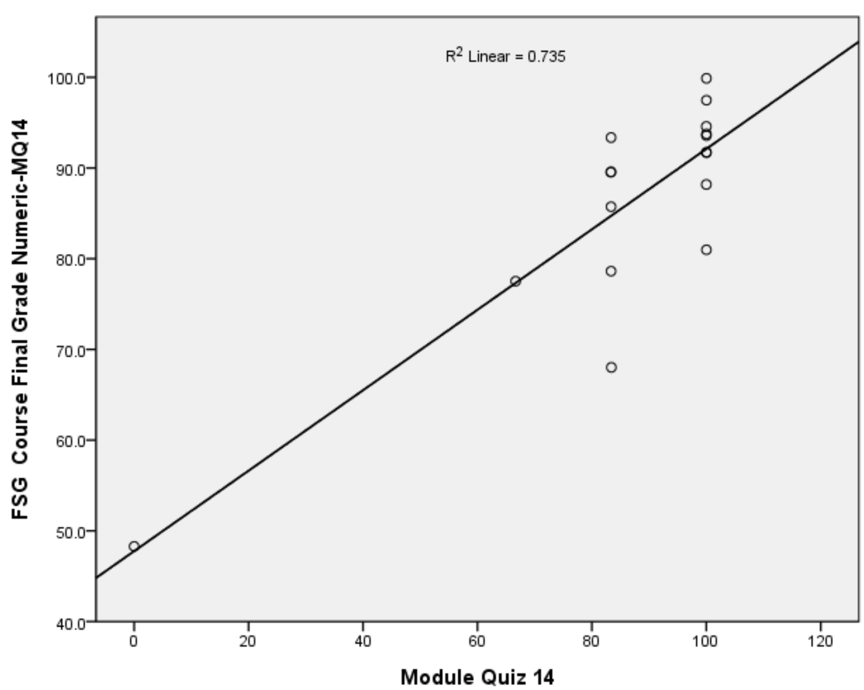


Figure D.5 Module Quiz Score vs. FSG Course Final Grade Numeric

Table D.11A Regression Results Experimental Group

Model Summary[c]					
Model		R	R Square	Adjusted R Square	Std. Error of the Estimate
	1	.857[a]	.735	.717	6.7313
	2	.939[b]	.881	.864	4.6656
a. Predictors: (Constant), MQ14					
b. Predictors: (Constant), MQ14, MQ6					
c. Dependent Variable: FG Num					

Table D.11B Regression Results Experimental Group

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	47.769	6.155		7.761	.000
	MQ14	.443	.069	.857	6.447	.000
2	(Constant)	12.545	9.500		1.321	.208
	MQ14	.320	.056	.619	5.694	.000
	MQ6	.500	.121	.451	4.150	.001
a. Dependent Variable: FG Num						

Based on a favorable regression as shown above, the 48 question group was reduced to only the questions contained in the most predictive chapters. The results of this selection reduced the question group to 8 questions as shown in Table D.12 below:

Table D.12 Eight Question Group based on Module Quiz Correlation (Control)

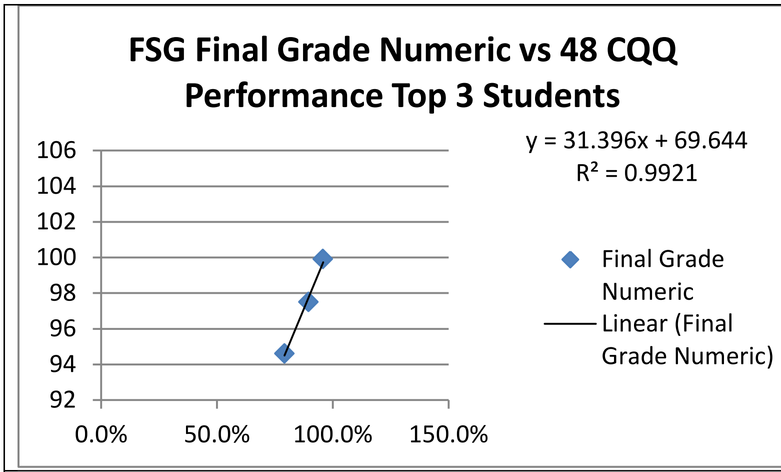
Question Name	Ch.	Ranking	+ Increase in % correct per?
LM6-MQ6A BSP 1	7	Med1	4.17
LM6-MQ6A BSP 2	7	Low	26.99
LM6-MQ6A MDP 1	7	Med2	19.82
LM6-MQ6A MDP 2	7	Low	34.28
LM6-MQ6A U & K HAM 1	7	Low	4.08
LM6-MQ6A U & K HAM 2	7	Med1	4
LM14-Q14A GPS CSCC	13	Med	16.02
LM14-Q14A RCS	13	Med	4.87

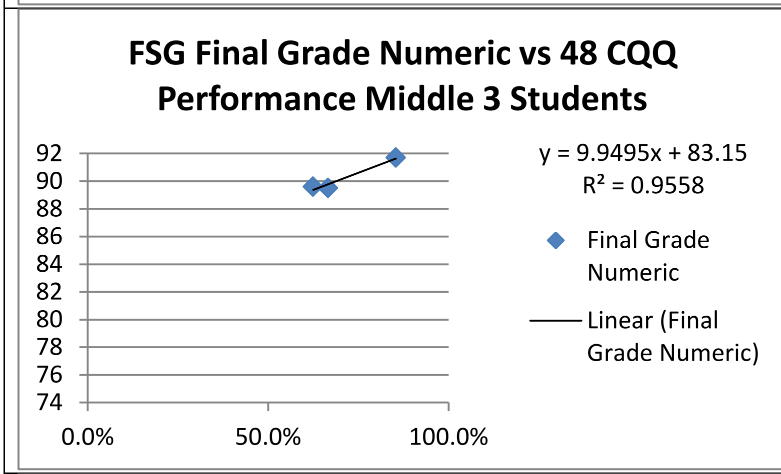
In order to review the predictability of this question group, the top, middle and bottom three student performances representing the experimental course offerings were selected and applied to the full 48 question group and the reduced 8 question group. The results of the analysis are shown in Tables D.13 and D.14. A review of the tables shows the categories. The behavior for the 48 question group and the 18 question group show much better trends and are operating at the upper end chart that indicates higher averages. Based on the trends and upper level grade position, it may be possible that the 8 question group may predict the course performance-Final Grade Numeric in a similar way as the 48 question group. More data is needed to test the predictive power of the 8 CQQ group.

Finally, it should be noted that based on a comparison of the Final Grade Numeric versus the 48 CQQ plots in Tables D.9 and D.13 (Control & Experimental), the following items can be observed:

- For all three student groups; top, middle and bottom, the experimental group performance exceeded the control group performance.
- The R-Square values trended higher for the experimental group in two of the three student cases (high and medium).
- Both the control group and the experimental group exhibited positive slopes for all three student cases.

Table D.13 Results of FSG Final Grade Numeric vs 48 CQQ





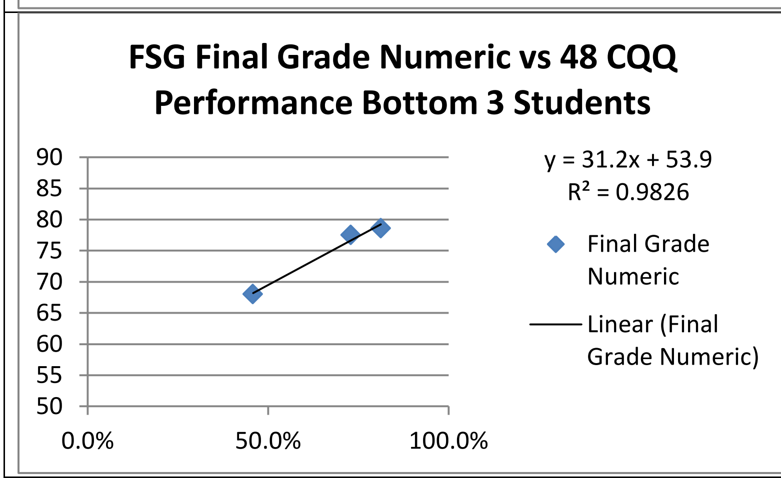
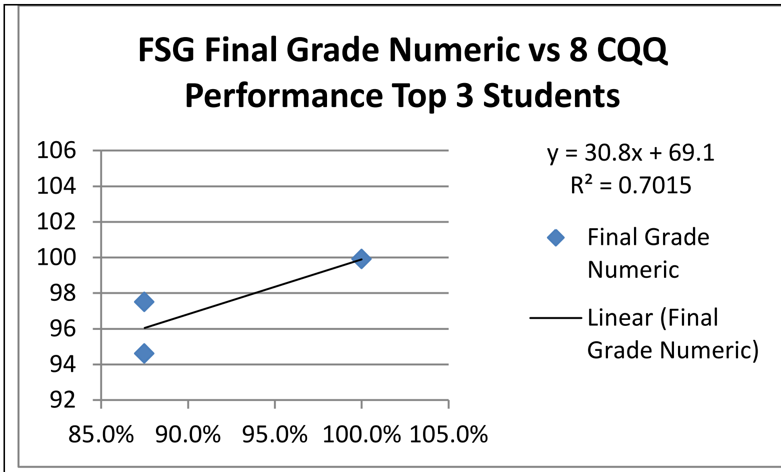
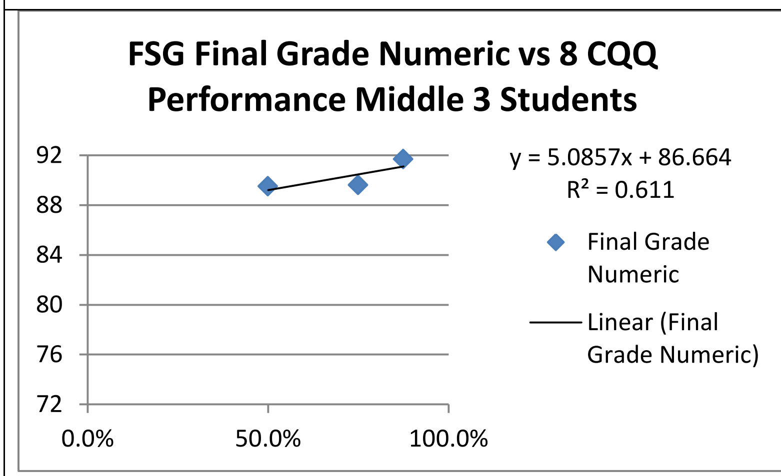
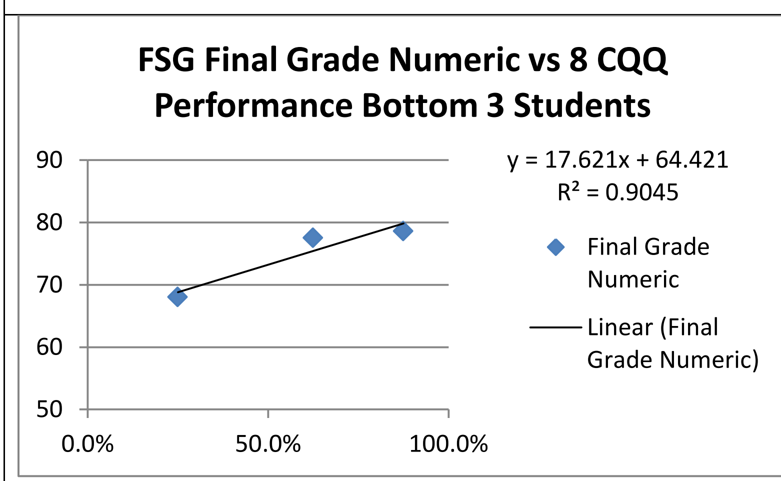


Table D.14 Results of FSG Final Grade Numeric vs 8 CQQ







REFERENCES

Al-Shammari, Z. M., A and Al-Shammari, B. (2010). An Investigation of the Effectiveness of Increasing Academic Learning Time for College Undergraduate Students' Achievement in Kuwait. *College Student Journal, 44(1)*, 148-156.

ABET-Viewpoints-IAC. (2000). "Viewpoints: Distance Education". *I*, 8-10. Retrieved from http://www.abet.org.

ABET-Criteria for Accrediting Applied Science Programs. (n.d.). Retrieved from http://www.abet.org.

ABET - Online Programs. (n.d.). Retrieved from http://www.abet.org/online-programs/.

Anon. (2005). Are High School Grades Inflated? *Issues in College Readiness*: ACT (formerly: American College Testing).

Anon. (2011-2013). *Middle Georgia College Catalog*. Retrieved March 13, 2014, from http://www.mga.edu/academics/docs/catalogs/mgc/MGC_2011-2013_Catalog.pdf.

Anon. (2013). *Georgia Board of Professional Engineers & Land Surveyors*. State of Georgia. Retrieved March 13, 2014, from http://sos.ga.gov/index.php/licensing/plb/22.

Anon. (2013-2014). *Middle Georgia State College Catalog*. Retrieved March 13, 2014, from http://www.mga.edu/academics/docs/catalogs/MGSC_2013-2014_Catalog.pdf

Anon. (2014). Freshman Admissions. Retrieved March 24, 2014, 2014, from http://www.spsu.edu/undergraduate/admission/freshman.htm.

Anon. (2014). Georgia General Assembly Legislation. Retrieved March 13, 2014, from http://www.legis.ga.gov/en-US/default.aspx

Great Basin College Website-Admissions. (n.d.). Retrieved from http://www.gbcnv.edu.

Baehr, M., and Beyerlein, Steven W. (2007). Overview of Assessment. In S. W. Beyerlein, Holmes, Carol, and Apple, Daniel, K (Ed.), *Faculty Guidebook* (4th ed., pp. 437-440): Pacific Crest.

Barnes, G. (2009). Geomatics at the Crossroads: Time for a New Paradigm in Geomatics Education? *Surveying and Land Information Science, 69(2)*, 81-88.

Barrett, S. F., LeFevre, E.W., Steadman, J.W., Tietjen, J.S., White, K.R., and Whitman, D.L. (2010). Using the Fundamentals of Engineering (FE) Examination as an Outcomes Assessment Tool (pp. 18): National Council of Examiners for Engineering and Surveying.

Besterfield-Sacre, M., Atman, C. J., & Shuman, L. J. (1997). Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering. *Journal of Engineering Education, 86*(2), 139-149. doi: 10.1002/j.2168-9830.1997.tb00277.x.

Bethel, J. (2011). Imaging Body of Knowledge for the Professional Surveyor. *Surveying and Land Information Science, 71(3-4)*, 147-156.

Bloom, B. Blooms's Taxonomy Graph, Accessed May 3, 2014. Metamediausa.com, (derived from Taxonomy of Educational Objectives: The Classification of Educational Goals by Benjamin Bloom. Et al., 1956).1]

Burkholder, E. (2008). Editorial. *ASCE: Journal of Surveying Engineering, 134(1)*, 1-2.

Burtch, R. (2005). *Surveying Education and Technology: Who's Zooming Who?* Paper presented at the Surveying and Mapping Educators Conference 2005, Corpus Christi, TX.

Chappuis, J. (2009). *Seven Strategies of Assessment for Learning* (1st. ed.). Boston, MA: Pearson.

Crossfield, J. K. (2005). How Geomatics Professional Employment Characteristics Impact Four-Year Educational Programs *SurveyPath*. http://surveypath.org/files/PDFs/Article1.pdf.

Elithorp, J. A., Jr. (2003). Student Information-Great Basin College Website. Retrieved March 13, 2014, from http://www.gbcnv.edu/.

Elithorp, J. A., Jr. (2007). Issues with the Provision of an Online Four-Year Degree Program in Land Surveying/Geomatics. *Surveying and Land Information Science, 67(4)*, 215-222.

Elithorp Jr, J. A. (2010). Matching Educational Methods to Student Profiles in Online Surveying and Mapping Programs. *Surveying and Land Information Science, 70(1)*, 5-11.

Field, K. (2005). 'Maps still matter -- don't they?'. *Cartographic Journal, 42(2)*, 81-82.

Forrest, D. (2003). Cartographic Education and Research in the UK. *Cartographic Journal, 40(2)*, 141-146.

Frank, S. (2008). *Learning Outcome Assessment - Setting and Measuring Goals*. Paper presented at the FIG Working Week 2008, Stockholm, Sweden.

Frank, S., Mansberger, R., Car, A., Petch, J. and Frunzi, N. . (2010). Enhancing Surveying Education through e-Learning *A Publication of FIG Commission 2 - Professional Education*: International Federation of Surveyors.

French, B. F., Immekus, J. C., & Oakes, W. C. (2005). An Examination of Indicators of Engineering Students' Success and Persistence. *Journal of Engineering Education, 94*(4), 419.

Gay, L. R., Mills, G.E. and Airasian, P. (2009). *Educational Research Competencies for Analysis and Applications* (9th ed.). Saddle River, New Jersey Pearson.

Gay, L. R., Mills, G.E. and Airasian, P. (2009). *Educational Research Competencies for Analysis and Applications*. New Jersey: Merrill.

Georgia S.O.S.- Georgia Board of Professional Engineers & Land Surveyors. (n.d.). Retrieved from http://sos.ga.gov/index.php/licensing/plb/22.

Ghilani, C. D. and Wolf, P.R. (2008). *Elementary Surveying An Introduction to Geomatics*. 12th ed. N.J.: Pearson Prentice Hall.

Greenfeld, J., & Potts, L. (2008). Surveying Body of Knowledge Preparing Professional Surveyors for the 21st Century. *Surveying and Land Information Science, 68(3)*, 133-143.

Greenfeld, J. (2011). GIS Body of Knowledge for Surveying. *Surveying and Land Information Science, 71(3-4)*, 115-133.

Greenfeld, J. (2011). Surveying Body of Knowledge. *Surveying and Land Information Science, 71(3-4)*, 105-113.

Kavanaugh, B. (2009). *Surveying Principles and Applications*. 8th ed. N.J.: Pearson Prentice Hall

Lathrop, W. (2011). Surveying Body of Knowledge and Stewardship. *Surveying and Land Information Science, 71(3-4)*, 173-182.

Lathrop, W., & Lucas, J. N. . (2011). Surveying's Legal Body of Knowledge. *Surveying and Land Information Science, 71(3-4)*, 157-171.

Levin, E., Liimakka, R., & Leick, A. (2010). Implementing a New Geospatial Educational Paradigm at Michigan Tech. *Surveying and Land Information Science, 70(4)*, 211-216.

McBeath, R. J. (1992). *Instructing and evaluating in higher education:*. Englewood Cliffs, N.J. : Engineering Technology Publications.

McKinny, B., J. (2011). *MSED 7132 Assessment of Student Learning*. Class Notes. Statesboro, GA.

Means, B., Toyama, Y., Murphy, R., Bakia, M., and Jones, K. . (2010). *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*. Washington, D.C.: Office of Planning, Evaluation and Policy Development.

Mertler, C. A. (2003). *Classroom Assessment* (1st. ed.): Pyrczak Publishing.

Middle Georgia State College. (n.d.). Student Data. Retrieved from http://www.mga.edu/course-schedule/.

Middle Georgia State College-Office of Planning, Advising and Research. (2011). Surveying Student Data. Cochran, GA.

Moller-Wong, C., & Eide, A. (1997). An Engineering Student Retention Study. *Journal of Engineering Education, 86*(1), 7-15.

NCEES. (2011). Benefits of a Four-Year Degree for Surveying Licensure. Retrieved March 13,2013, from http://ncees.org/.

NCEES. Model Law (2012). Retrieved March 13,2013, from http://ncees.org/.

NCEES. (2013). NCEES Web Site. Retrieved March 13,2013, from http://ncees.org/.

Newgren, K. (2007). Designing a Foundation Course. In S. Beyerlein, W., Holmes, Carol, Apple, Daniel, K. (Ed.), *Faculty Guidebook* (4th ed., pp. 269-272): Pacific Crest.

Paiva, J. (2011). Surveying Body of Knowledge for Positioning. *Surveying and Land Information Science, 71(3-4)*, 135-145.

Potts, L. V. (2010). The Surveying Body of Knowledge of Hybrid Learning. *Surveying and Land Information Science, 70(1)*, 13-22.

Purcell, R. C. and Butler, J.H. (2004). *Technical Standards Session 2004 Summer Meeting - Surveying and Mapping Society of Georgia*. Paper presented at the 2004 Summer Meeting - Surveying and Mapping Society of Georgia, Brasstown, GA.

Qing, L. I., Swaminathan, H., & Jiong, T. (2009). Development of a Classification System for Engineering Student Characteristics Affecting College Enrollment and Retention. *Journal of Engineering Education, 98(4)*, 361-376.

Reid, J., Perkins, C., Dodge, M., Shephard, I., Chilton,C., Faiburn, D. (2011). Education. *Cartographic Journal, 48(3)*, 207-213.

Roy, F. (2012). *Evolution of Geomatics Curriculum: Adding new knowledge without lengthening studies*. Paper presented at the Fig Working Week 2012, Rome, Italy.

Seybert, T. A. (2008). Evaluating Program Outcomes and Classroom Instruction on the Basis of Course Outcomes Assessment. *Surveying and Land Information Science, 68(3)*, 125-132.

Shortis, M. R., Leahy, F.J., Ogleby, C.L., Kealy, A. and Ellis, F.G. (2004). Web-based learning of spatial design and analysis concepts using simulations and visual feedback. *Directorate of Overseas Surveys*.

Soceiro, A. and Cabral, J.S. (2004). Engineering students' assessment at University of Porto. *European Journal of Engineering Education, 29(2)*, 283-290.

Soler, T. (2010). Advocating a Renewed Culture of Surveying Education. *Journal of Surveying Engineering, 136(3)*, 101-101.

Southern Polytechnic State University. (n.d.). Student Enrollment Schedule. Retrieved from https://banweb.spsu.edu/pls/PROD/schedule.main.

Stiggins, R. (2007). Assessment Through The Student's Eyes. *Educational Leadership, May 2007*, 22-26.

Uhumuavbi, P. O., & Mamudu, J. A. (2009). Relative Effects of Programmed Instruction and Demonstration Methods on Students' Academic Performance in Science. *College Student Journal, 43(2)*, 658-668.

Wicks, M., A. (Ed.), (2007). Creating Meaningful Assessment and Documentation Systems. In W. S. Beyerlein, Holmes, Carol, Apple, Daniel, K (Ed.), *Faculty Guidebook* (4th ed., pp. 335-336): Pacific Crest.

Wiggins, G. (2008). Assessment as Feedback. *New Horizons for Learning-Teaching and Learning Strategies*. Pearson.

Wiggins, G. & Jay, M. (2005). *Understanding by Design*: Pearson.

Wijayratne, I. D. (2005). *A Bachelor Degree Program in Surveying/Geomatics Offered to Placebound Students: Measuring Success*. Paper presented at the FIG Working Week 2005.

Wissa, M., & Bajracharya, R. R. (2007). Tailoring a Geomatics Curriculum to Prepare Students for Professional Licensing and Success in the Workplace. *Surveying and Land Information Science, 67(4)*, 233-244.

Wolf, P. (2002). Surveying and Mapping: History, Current Status, and Future Projections. *Journal of Surveying Engineering, 128(3)*, 79-107.